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MISSION SAFETY EVALUATION REPORT FOR STS-29

Postflight Edition: May 8, 1989

Safety Division

Office of Safety, Reliability, Maintainability and Quality Assurance

National Aeronautics and Space Administration

Washington, DC 20546

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FOREWORD

The Mission Safety Evaluation (MSE) is a National Aeronautics and Space Administration (NASA) Headquarters Safety Division, Code QS produced document that is prepared for use by the NASA Associate Administrator, Office of Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) and the National Space Transportation System (NSTS) Program Manager prior to each NSTS flight. The intent of the MSE is to document significant safety risk factors that represent a change, or potential change, to the risk baselined by the Program Requirements Control Board (PRCB) in the NSTS Hazard Reports. It also documents unresolved safety risk factors impacting the STS-29 flight.

The MSE is published on a mission-by-mission basis for use in the Flight Readiness Review (FRR) and is updated for the Launch Minus 2 Day (L-2) Review. For tracking and archival purposes, the MSE is issued in final postflight report format after each NSTS flight.

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Section 1

INTRODUCTION

1.1 Purpose

The Mission Safety Evaluation (MSE) provides the Associate Administrator, Office of Safety, Reliability, Maintainability and Quality Assurance (SRM&QA) and the National Space Transportation System (NSTS) Program Manager with the NASA Headquarters Safety Division position on significant changes, or potential changes, to the Program safety risk baseline approved in the formal Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) and Hazard Analysis process. While some changes to the baseline since the previous flight are included to highlight their significance in risk level change, the primary purpose is to ensure that changes which were too late to include in formal changes through the FMEA/CIL and Hazard Analysis process are documented along with the safety position, which includes the acceptance rationale.

1.2 Scope

This report addresses STS-29 safety risk factors that represent a significant change from previous flights, factors from previous flights that have impact on this flight, and factors that are unique to this flight.

Factors listed in the MSE are essentially limited to items that significantly (or have the potential to) affect NSTS safety risk factors and have been elevated to Level I for discussion or approval. These changes are derived from a variety of sources such as issues, concerns, problems, and anomalies. It is not the intent to attempt to scour lower level files for items dispositioned and closed at those levels and report them here; it is assumed that their significance is such that Level I discussion or approval is not appropriate for them. Items against which there is clearly no safety impact or potential concern will not be reported here, although items that were evaluated at some length and found not to be a concern will be reported as such. NASA Safety Reporting System (NSRS) issues are considered along with the other factors, but may not be specifically identified as such.

Data gathering is a continuous process. However, collating and focusing of MSE data for a specific mission begins prior to the mission Launch Site Flow Review (LSFR) and continues through the flight and return of the Orbiter to Kennedy Space Center (KSC). For archival purposes, the MSE will be updated subsequent to the mission to add items identified too late for inclusion in the prelaunch report and to document performance of the anomalous systems for possible future use in safety evaluations.

1.3 Organization

The MSE is presented in seven sections as follows:

Section 1 - Provides brief introductory remarks, including purpose, scope, and organization.

Section 2 - Provides a summary description of the STS-29 mission; a brief flight/vehicle description, including launch data, crew size, flight duration, launch and landing sites, and other related information; and a brief payload description.

Section 3 - Contains a summary listing of significant safety risk factors/issues, considered resolved or not a safety concern prior to STS-29 launch, that were impacted or repeated by anomalies reported for the STS-29 flight.

Section 4 - Contains a summary listing of significant safety risk factors that are considered resolved for STS-29.

Section 5 - Contains a summary listing of significant safety-of-flight problems that developed during the STS-27 mission.

Section 6 - Contains a summary listing of significant safety-of-flight problems that developed during the STS-26 mission.

Section 7 - Contains background and historical data on the issues, problems, concerns, and anomalies addressed in Sections 3 through 6. This section is not normally provided as part of the MSE, but is available upon request. It contains (in notebook format) presentation data, white papers, and other documentation. These data were used to support the resolution rationale or retention of open status for each item discussed in the MSE.

Appendix A - Contains the official STS-29 Inflight Anomaly (IFA) Report. This report is included for completeness and reference purposes. Those STS-29 IFAs which are considered to represent significant safety risks will be addressed in the MSE for the next NSTS flight.

Appendix B - Contains a list of the acronyms used in this report.

Section 2

STS-29 MISSION SUMMARY

2.1 Summary Description of STS-29 Mission

Space Shuttle *Discovery* was launched from Kennedy Space Center (KSC) at 9:57 A.M. EST on March 13, 1989. The primary objective of the STS-29 mission, deployment of a Tracking and Data Relay Satellite/Inertial Upper Stage (TDRS-D/IUS), was successfully accomplished. Six hours after liftoff, the crew deployed the TDRS-D satellite from *Discovery's* payload bay. *Discovery* was maneuvered to a safe position behind and above the TDRS-D/IUS, and the first stage of the two-stage IUS motor was ignited to maneuver TDRS to the desired attitude for subsequent boost into geosynchronous orbit. After a successful flight of almost 5-days duration, *Discovery* landed at Edwards Air Force Base at 9:35 A.M. EST on March 17, 1989.

The TDRS-D communications satellite is the third spacecraft deployed as part of NASA's Tracking and Data Relay Satellite System (TDRSS). TDRS-D is located at 41 degrees W. longitude, east of Brazil. It replaces TDRS-A, deployed on STS-6 in April 1983, which has been moved to a parking orbit and will be used only if a failure occurs on one of the remaining satellites. Three TDRS satellites, operating from geosynchronous orbit, are required to complete the constellation known as TDRSS. TDRSS increases communications between Earth-orbiting spacecraft and a ground-based tracking station from 15 to 85 percent per orbit, and facilitates a much higher rate of data flow.

Secondary objectives of STS-29 were successfully accomplished, including performance of attached cargo operations for the Orbiter Experiments Autonomous Supporting Instrumentation System (OASIS-1) and Space Station Heat Pipe Advanced Radiator Element (SHARE), and performance of a number of middeck experiments. A complete list of payload bay and middeck experiments cargo is contained in Section 2.3.

2.2 Flight/Vehicle Data

- Launch Date: March 13, 1989
- Launch Time: 9:57 A.M. EST
- Launch Site: KSC Pad 39B
- Landing Site: Edwards AFB, CA, Lakebed.
- RTLS: Kennedy Space Center, Runway 33
- TAL Site: Ben Guerir, Morocco
- AOA: Edwards AFB, CA
- Mission Duration: 4 Days, 23 Hours, 38 Minutes
- Crew Size: 5
- Inclination: 28.45 Degrees
- Altitude: 160 Nautical Miles/Direct Insertion
- Orbiter: OV-103 (8) Discovery
- SSMEs: 2022, 2028, 2031
- ET: ET-36
- SRBs: BI-031
- Total Cargo Weight: 44,792 Pounds
- Orbiter Weight, Including Cargo: 263,289 Pounds (at SRB Ignition)
- Total Vehicle Weight at SRB Ignition: 4,525,139 Pounds
- Orbiter Landing Weight: 194,616 Pounds

2.3 Payload Data

- Payload Bay

  - Tracking and Data Relay Satellite/Inertial Upper Stage (TDRS-D/IUS)

  - Orbiter Experiments Autonomous Supporting Instrumentation System (OASIS-1)

  - Space Station Heat Pipe Advanced Radiator Element (SHARE)

  - Shuttle Solar Backscatter Ultraviolet (SSBUV)

  - Getaway Special (4)

- Middeck

  - Chromosomes and Plant Cells Division in Space Experiment (CHROMEX)

  - IMAX Camera System (Middeck)

  - Polymer Morphology (PM) Experiment

  - Protein Crystal Growth (PCG)

  - Shuttle Student Involvement Project SE82-8 (Bone Healing Experiment)

  - Shuttle Student Involvement Project SE83-9 (Chicken Embryo Development in Space)

  - Air Force Maui Optical System (AMOS)

Section 3

SAFETY RISK FACTORS/ISSUES IMPACTED BY STS-29 ANOMALIES

This section contains a summary list of the significant safety risk factors/issues, considered resolved or not a safety concern for STS-29 prior to launch (see Sections 4, 5, and 6), that were impacted or repeated by anomalies reported for the STS-29 flight. The list indicates the section of this MSE in which the item is addressed, the item designation (Element/Number) within that section, a description of the item, and brief comments concerning the anomalous condition that was reported. (Anomalies that arose during the STS-29 flight, that were not preflight safety risk factors/issues, can be found in the complete STS-29 official inflight anomaly report contained in Appendix A.)

	ITEM	COMMENT

Section 4: Resolved Significant Safety Risk Factors

SSME 1	Gaseous Oxygen (GOX) Flow Control Valves (FCVs) can lock up due to contamination.	Sluggish operation occurred again on STS-29 during the first cycle. This anomaly is being investigated, although there was no mission degradation and the FCVs cycled well on all cycles subsequent to the first. This risk factor will be readdressed in the STS-30 MSE.
SSME 4	Nozzle coolant tube protrusion into the flow stream at the Main Combustion Chamber (MCC)/nozzle interface can cause excessive heating.	Although there was a liquid hydrogen (LH_2) leak at the MCC/nozzle interface due to braze failure, there was no indication that coolant tube protrusion was the cause. There has been no report of excessive temperature at the seal. This risk factor will be readdressed in the STS-30 MSE.
SRM 1	An incident during QM-8 tests gave rise to concern about Kapton insulation flammability and premature ignition of Redesigned Solid Rocket Motor (RSRM) propellant from igniter heater short circuit.	The right aft field heater joint failed during the STS-29 prelaunch period. The secondary heater was subsequently used and operated satisfactorily. Twenty-ampere fast acting circuit breakers will be implemented to protect this circuit for STS-30. Twenty-ampere instant trip Ground Fault Interrupts (GFIs) will be implemented for flights after STS-30.

Section 5: STS-27 Inflight Anomalies

SRM 4	Bolt damage in aft-fwd exit cone joint.	Extensive damage was experienced again from STS-29 water impact. This is not a safety issue because the damaged parts are discarded. But loss of hardware is a concern which will be tracked outside of the MSE.

Section 4

RESOLVED STS-29 SAFETY RISK FACTORS

This section contains a summary listing of the significant safety risk factors that were considered resolved for STS-29. These items were reviewed by the NASA safety community. A description and information regarding problem resolution are provided for each safety risk factor. The safety position with respect to resolution is based on findings resulting from System Safety Review Panel (SSRP) and Program Control Review Board reviews (or other special panel findings). It represents the safety assessment arrived at in accordance with actions taken, efforts conducted, and tests/retests and inspections performed to resolve each specific problem.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
INTEGRATION		
1	All crew members felt a low-frequency vibration/buffet during STS-27 second stage that was not present on their previous flights. HR No. INTG-005 P.02	A 3-4 Hertz longitudinal motion persisted to Main Engine Cutoff (MECO). Similar "rumbles" have been reported on two flights of OV-103 (STS-41D, STS-51C). This low-frequency vibration reported by the crew is consistent with preflight analysis. The POGO loop is adequately damped. The Digital Autopilot (DAP) properly attenuates modes of significance to the Flight Control System (FCS). The structural response is normal to Space Shuttle Main Engine (SSME) thrust fluctuation. The phenomenon changes with payload and time in flight. It has occurred before and will likely recur in the future. This risk factor is not a safety concern for STS-29. Loads are well within the acceptable range.
2	Potential ET/Orbiter recontact upon separation during Return to Launch Site (RTLS). HR No. INTG-010 ***Because RTLS abort was not experienced on STS-29, this risk factor was not a consideration.***	External Tank (ET) separation dispersion refinements have been made. Tail down uncertainty is the new driver; previously, nose down uncertainty was the principal driver. Reevaluation of ET separation indicated potential for umbilical recontact during normal and systems RTLS. Software Change Request (CR) 89948 was approved for STS-29 and subsequent flights to eliminate the potential recontact. This change increases the open loop (Z-translation maneuver) timer from 1.0 to 4.0 seconds. Waivers were approved for Vol. X separation envelope requirement exceedance. There is no impact on safe Orbiter separation control and return. With the revised timer, this risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
INTEGRATION		
3	High strength critical fasteners (MD series) supplied by Fairchild Industries/Voi-Shan Division may fail due to hydrogen embrittlement. The supplier did not verify fasteners met specifications through certification testing, as required. HR No. ORBI-277 ***No anomalies were experienced on STS-29.***	Voi-Shan is currently suspected of falsely certifying high strength series MD fasteners. Series MD fasteners are used in the primary structure of each Orbiter and other Elements. Current stock is being inspected for questionable fasteners, identified by Voi-Shan Inspection Stamp No. 11, alleged to be a bogus stamp which is not assigned to a Voi-Shan inspector. An NSTS Teletype Wire Transmission (TWX) alert has been sent to all NASA Centers. Quality Engineering at NASA/Johnson Space Center (JSC) and Rockwell/Downey are investigating the extent of certification tests done at Voi-Shan and the Rockwell purchase of Voi-Shan fasteners, and are examining Rockwell incoming inspection data on the series MD fasteners. The current focus is to identify use on OV-103, STS-29. To date, Rockwell has no record of a Voi-Shan fastener failure on any Orbiter or Orbiter hardware item. No manufacturer test reports have been found with an Inspector No. 11 stamp. There is still a concern for titanium bolts in the forward Primary Thruster; retesting is being performed to ensure acceptable hydrogen content. SSME: Rocketdyne performed or witnessed tensile, material, and metallurgical tests on all lots of fasteners. Additional tests have been conducted at Rocketdyne since February 16, 1989. Thirty-five of 220 fasteners in stock were sampled/tested. All were acceptable, including some from Inspector No. 11 lots. Procured subassemblies are being reviewed. There is currently no concern for STS-29 engines. ET: Voi-Shan supplied fasteners (3 lots) used on ET-36 have all been test verified and have a minimum factor of safety in areas of use of 3.37:1. Vendor suppliers are being reviewed. No current issue on ET applications.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
INTEGRATION		
3 (Cont.)		Inertial Upper Stage (IUS): Boeing receiving inspections and tests are adequate to detect discrepant fasteners. Fasteners were tested from 206 Vol-Shan lots with no test failures. Not an issue for STS-29 IUS stages. SRB: Many Vol-Shan callouts on United Space Booster, Inc. (USBI) drawings. Subcontractors are still researching Vol-Shan usage. Testing is still in progress, including part numbers (P/Ns) known to have been procured from lots with the inspector No. 11 stamp. No failures have occurred. Solid Rocket Motor (SRM): Vol-Shan fasteners not currently used. Not an issue. Data on identification of usage has been gathered and examined, testing accomplished, and reported problems have been collected. Based on results received, i.e., no failures reported on testing and in the program, assessment indicates that there is no hardware problem impact STS-29. Data will continue to be gathered to determine if there is a program impact. This risk factor is an acceptable safety risk based on the extensive investigation and testing to date, and is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>INTEGRATION</u>		
4	Revision to ET and SRB protuberance airloads needs to be assessed. HR No. ORBI-249 ORBI-272 ***There was a protuberance load issue that indicated the potential for ascent load exceedance. Computation of loads for the specific case found that the ET was within the design specification envelope.***	Newly developed loads data for ET and SRB protuberances has been developed by Program Integration and sent to the ET and SRB Projects. Updated protuberance airload preliminary assessments have been completed by the projects. Although the new airloads are significantly higher than previously used loads, all affected components have been assessed to meet the minimum required factor of safety. Data was presented to the Level I PRCB on March 9, 1989. This risk factor is resolved for STS-29.
<u>ORBITER</u>		
1	STS-27 Thermal Protection System (TPS) damage. STS-27R suffered significantly greater tile damage than any previous successful mission. HR No. INTG-037A ***Postflight inspection found that the Orbiter TPS experienced the least damage than any flight to date. Corrective actions implemented for STS-29 were very successful.***	An STS-27 TPS Damage Review Team was established on December 9, 1988. The TPS team reported that the most probable cause of the severe Orbiter tile damage is that the ablative insulating material covering the right SRB nose cap dislodged and struck the Orbiter tile approximately 85 seconds into flight. It is possible that debris from other sources, including repaired ET insulation and solid rocket motor joint cork, caused minor tile damage. Corrective actions implemented for STS-29 include: the MSA-1 ablative was replaced by MSA-2 which has much better physical characteristics, including higher tensile strength; the processes of application and inspection are more tightly controlled; SRB cork materials are inspected and tap tested for voids, repaired, and vent holes drilled, as required. ET/TPS test verified bond integrity. Actions taken make this risk factor an acceptable risk for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>ORBITER</u>		
2	STS-29 tire inflation valves were overtorqued to 190-210 inch-pounds instead of the correct 70-80 inch-pounds specification range. Failure of the valve prior to landing could result in loss of the Orbiter and the crew. HR No. ORBI-018 ORBI-021 ORBI-185 ***Postflight inspection showed no indication of failure or incipient failure.***	Prior to STS-27, inflation valves were installed at B.F. Goodrich to the specification requirement torque of 70-80 inch-pounds and with locktite on the threads. The Operational Maintenance and Requirements Document (OMRSD) erroneously called for 190-210 inch-pounds torque with locktite on the threads. The inflation valves on two STS-29 tire/wheel assemblies (OV-103) and four STS-30 assemblies (OV-104) were removed and replaced at KSC, and were torqued to the erroneous Rockwell specification value. Tests were conducted at B.F. Goodrich using a specification wheel and inflation valves with locktite on the threads. Yielding occurred at 190-210 inch-pounds, with failure at 250 inch-pounds. Tests conducted at KSC with flight type wheels, valves with locktite on the threads, and torquing to 210 inch-pounds resulted in no detrimental effects. Also, upon yield, additional strength is picked up due to work hardening. Dye penetration, 30X magnification, and 500X magnification were used in the tests. The JSC Mechanical and Analysis Branches also indicated that at yield torque the yielding should be quite apparent. The technician who installed the valves at KSC stated that he recalled no feeling of yielding at the 190-210 inch-pounds overtorque. However, it is not certain that yield did not occur. A coordinated JSC/Rockwell mechanical stress analysis of the structural integrity of the overtorqued inflation valve revealed that approximately 5000-g loads are required to increase stress loads in the valve critical area. The design shock load for the tire/wheel assembly is approximately 50 g at touchdown; the resulting safety factor is 100.

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
ORBITER		
2 (Cont.)		Even if the valve fails, B.F. Goodrich analysis indicates the rate of loss of tire pressure upon landing is too slow to cause tire failure. The tire deflation testing (simulated valve failure at landing) indicated a pressure decrease from 355 to 300 pounds per square inch (psi) in 23 seconds; pressure decrease from 355 to 0 psi in 550 seconds. Time from Main Landing Gear (MLG) wheel touchdown to Nose Landing Gear (NLG) wheel touchdown is less than 20 seconds nominal. Time from MLG wheel touchdown to wheel stop is less than 60 seconds nominal. Rockwell has prepared and forwarded certification of the overtorqued valves for STS-29 and STS-30. B.F. Goodrich has deferred to Rockwell's judgment on this matter. The torque specification is being changed to the correct 70-80 inch-pounds for STS-28 and subsequent flights. The safety position is that testing and analysis indicate a reasonable margin of safety even at high torque levels. This risk factor is resolved for STS-29.
3	STS-29 Schraeder valve tire leakage. HR No. ORBI-018 ORBI-021 ORBI-185 ***Postflight inspection indicated no excessive leakage. Tire pressure was good on all wheels.***	The Right-Hand (RH) and Left-Hand (LH) Nose Wheel Assembly (NWA) installed on OV-103 experienced leaks. Current RH/LH NWAs have been replaced with assemblies which are flight certified and have lower established leak rates (0.20-0.24 psi/day). In addition, the leakage measurements were made without the valve cap which is the primary seal. This risk factor is not a safety concern for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
ORBITER		
4	Elevon blade pins were missing on OV-104. Lost pins could have jammed the Elevon actuator. HR No. ORBI-003 ***Postflight inspection found no missing Elevon blade pins.***	The problem was caused by welds that were contaminated. More rigorous inspection of welds was implemented for STS-29. All inspected welds were satisfactory. This risk factor is an acceptable risk for STS-29 based on inspection results.
5	Payload bay insulation blankets were found wrapped up on OV-104 (January 1989) and OV-103 (October 1988). Seventeen additional occurrences were recorded on Problem Reports (PRs). HR No. ORBI-305A ***Postflight inspection found no blankets wrapped around the payload bay doors.***	Thermal Control System (TCS) insulation blankets can wrap around the payload bay door drive shaft and potentially inhibit door closure. There are protuberances that can snag the insulation blankets and result in wrapping around the door drive shaft. Should the blanket become ensnared, analysis indicates there is sufficient torque to drive the doors closed (but at a slower-than-normal rate). Testing was performed at Downey with duplicated wrapup conditions. Torque on the shaft to wrap the worst case blanket is 200 inch-pounds. Pressure Disconnect Valve (PDV) stall torque available is 650 inch-pounds (minimum) as verified in the Acceptance Test Procedure (ATP). Nominal torque required is 220 inch-pounds (seals compressed and door in position for bulkhead latch engagement). Therefore, one-blanket worst case wrap leaves 230 inch-pounds margin (430-200); simultaneous two-blanket worst case wrap on the same side leaves 30 inch-pounds margin (230-200). Simultaneous two-blanket wrap on the same side still yields margin, with risk of an Extravehicular Activity (EVA). Potential modifications to eliminate the protuberances are being worked on. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
ORBITER		
6	Uncommanded brake pressure after MLG touchdown on STS-27. HR No. ORBI-234 ***There was no indication of anomalous brake pressure after MLG touchdown on STS-29.***	Pressure fluctuations up to 200 pounds per square inch absolute (psia) were experienced. This condition has been seen on previous flights and has been determined to result from pressure surges due to Elevon reposition movement. The Elevons are moved to full up after MLG contact. This risk factor is resolved for STS-29.
7	Loose tiles discovered in the OV-104 inboard Elevon cove area. HR No. ORBI-081 ***Postflight inspection found no loose tiles.***	A technician noticed a loose tile in the inboard Elevon cove area ("wiggled" when touched). Further tests on the LH and RH side of OV-104 identified additional loose tiles that were improperly bonded. These were original tiles installed at Rockwell/Palmdale that have flown on previous missions. The concern is that similarly located tiles on OV-103 may have been installed in a like manner and could have become unbonded. KSC performed test sampling of tiles on OV-103 inboard Elevon cove areas. One suspect tile was identified, a right-hand trailing edge tile. Although the suspect tile was installed at Palmdale and has flown all OV-103 flights, the gap filler was removed, and the tile was bonded to an adjacent tile for added bond strength as a precaution. This also eliminates the potential for hot gas flow into debond area. The tile has been approved for STS-29 only. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>ORBITER</u>		
8	Main Propulsion System (MPS) Main Engine (ME) 2 Helium System is leaking on OV-103. HR No. INTG-041 INTG-068 ***The leak apparently did not increase. No safety degradation was experienced.***	The MPS ME-2 Helium (He) System leak increased to an out-of-specification condition during a decay test at Launch Pad (LP) 39B. A helium tank pressure change was observed. During extensive troubleshooting and system leak checks to find the leak, it was determined that ME-2 He isolation solenoid valve (LV-4) had an external leak of 46 standard cubic inches per minute (scims) from the vent port valve while the valve is deenergized after engine shutdown. Cyclic testing has determined that the leak has stabilized at the measured rate. For a nominal 7-day mission, this equates to only 2.8 pounds of helium or a 20 psi per day pressure loss. Mission Operations Director (MOD) evaluation is that the total loss of this helium system after MECO would not affect the safety of the mission. This risk factor is resolved for STS-29.
9	Left-hand Orbital Maneuvering System (OMS) Pod Reaction Control System (RCS) Helium tank vent line leak. HR No. GSE-1 INTG-172 ORBI-054 ***Postflight inspection found no excessive leaks. Clamshells will be reevaluated prior to the next OV-103 flight.***	A leak was found at dynatube fitting prior to STS-26. The leak was repaired with installation of a clamshell backfilled with Furmanite (repair certified for 5 missions). "Fleet Leaders" at Rockwell have successfully demonstrated the clamshell concept. There has been no leakage to date, and propellant compatibility with Furmanite has been satisfactory for more than 170 days. Inspection of the clamshell after propellant loading for STS-29 confirms that there is no leaking. Rockwell has demonstrated the Remove and Replace (R&R) technique for the clamshell at JSC. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SSME		
1	Gaseous Oxygen (GOX) Flow Control Valves (FCVs) can lock up due to contamination. HR No. INTG-017 INTG-150A ET-T.01 ET-S.03 ET-S.05 ***Sluggish operation occurred again on STS-29 during the first cycle. This anomaly is being investigated, although there was no mission degradation and the FCVs cycled well on all cycles subsequent to the first. This risk factor will be addressed again in the STS-30 MSE.***	During checkout of the OV-104 GOX FCVs at KSC, it was found that in the pull-in/drop-out test at low voltage (0-8 volts), the FCV for ME-2 would not move from the high to low position (i.e., pull in). The valve was then cycled from 0 to 22 volts; still no movement. The valve was then energized with 28 volts, and the armature moved to the low flow position. Power was then removed, and the valve should have moved to the high flow (i.e., drop out); no movement was observed. As a result of the testing, it was determined that the armature was jammed. All 3 valve solenoid/poppet assemblies were removed and sent to Rockwell/Downey for failure analysis, with the following results being observed: (1) all 3 valves were contaminated, with ME-2 valve the worst of the three; (2) the particulate is similar to that seen in valves previously, with the size distribution conforming to a class 100 distribution with the exception of two 200+ micron-sized particles. The materials are 21-6-9 and 304 stainless, with the larger particles being the stainless. These valves were cleaned after OV-103 on STS-26 and flew previously on OV-104 on STS-27. This contamination is no different than that seen in every valve we have examined, and is less severe than what was seen in one of the STS-26 valves. Tolerances were opened up; however, it appears that in-specification contamination can still lock up the valves. The rationale for risk acceptance to permit flight on STS-29 is essentially the same as that arrived at for STS-26. Triple redundancy is represented by the three GOX valves. A positive safety margin exists in all worst case failure scenarios (the probability of which is considered very small), except for RTLS. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SSME		
2	NASA Safety Reporting System (NSRS) Report indicated that nuts on the SSME side of the quick disconnects are not safety wired. HR No. INTG-065 ***There was no indication of B-nuts backing off. These B-nuts will be safety-wired for subsequent flights. This risk factor is no longer an issue.***	Investigation revealed this to be the case. STS-27 was flown without safety wires based on documentation of adequate high levels of torque and closeout photos. A change was approved to add safety wires in future flights. There is no hardware change as the B-nuts already have provisions for the safety wires. This risk factor is resolved for STS-29.
3	SSME controller channel loss. HR No. INTG-019 INTG-165 ***No problems were experienced with STS-29 Controllers relative to this risk factor.***	Controller F-24 channel B failed to turn on during OV-104 engine 2030 (ME-2) initial checkout. The failure was isolated to a short circuit of the collector-base junction in power supply Q1 switching transistor. This is the first Collector-to-Base (C-B) junction failure in the program and the first Radio Corporation of America (RCA) transistor failure in the program. The controller tested satisfactory with replacement transistors. Tests to date have not duplicated the failure. This is considered an isolated incident and not a generic problem. This risk factor is not a safety concern for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SSME		
4	Nozzle coolant tube protrusion into the flow stream at the Main Combustion Chamber (MCC)/nozzle interface can cause excessive heating. HR No. ME-B5M ME-B5S ***Although there was a liquid hydrogen (LH_2) leak at the MCC/nozzle interface due to braze failure, there was no indication that coolant tube protusion was the cause. There has been no report of excessive temperature at the seal. This risk factor will be readdressed in the STS-30 MSE.***	Nozzle coolant tube protrusion into the flow stream causes seal heating. STS-26 ME-1 nozzle protrusion at 0.95 inches resulted in seal bluing and a crack. A maximum protrusion of 0.25 inches has been established based on inspection results. However, there is a 0.45-inch protrusion on STS-29 ME-3 nozzle reassembly due to growth caused by induced hot fire strain released at disassembly and allowance for measurement tolerances. Additional testing/analysis was performed to establish acceptability of STS-29 Engine 2028 (ME-3). This engine will be limited to 1 flight/1000 seconds maximum. This maintains a factor greater than 20 on time. Hot fire time on protrusions 0.45 inches and greater demonstrated that 841 seconds on 2031 (0.45 protrusion) produced a blued seal but no crack; 1830 seconds on 2011 (0.95 and 0.85 protrusion) produced a blued seal but no cracks. This risk factor is resolved for STS-29.
5	Gouges in High Pressure Fuel Turbopump (HPFTP) Turbine Discs curvic teeth may affect Low-Cycle Fatigue (LCF) life. HR No. INTG-042 ME-B7M ME-B1M *No anomaly reported on STS-29.*	Gouges and scratches were observed in curvic fillet radii on two first-stage turbine discs from development units being examined under magnification to map missing gold. All available first- and second-stage discs were then examined. Damage varies from disc to disc; discs plated prior to 1986 appear undamaged. The gouges affect LCF life by increasing stress concentration. Damage is caused by the gold removal process on the curvic teeth when excessive force is applied to the gold removal tool. Rework procedures are being established to preclude gouging. Confirmation of the damage cause correlated available discs with one mechanic who performed the rework improperly. Flight and development units in the field are being statused, and planning will be reviewed and revised if necessary. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SSME		
6	Broken HPFTP housing lugs and tip seals may break resulting in HPFTP failure. HR No. INTG-042 ***No report of additional lug loss or degraded performance. This risk factor will be readdressed in the STS-30 MSE.***	Lug and tip seal High-Cycle Fatigue (HCF) fractures/fragments were experienced prior to 1982, and the tip seals were redesigned to reduce transient loads. Five HCF fractures have been experienced in 1988/1989. Current assessment of the failure cause is out-of-tolerance parts, dual pilot relative deflection effects, thermal induced deflections, and acoustic tuning. STS-29 units passed post green run and post STS-26 inspections. Prior benign experience with lug fractures indicates no incidents in 24 builds. There are also 11 instances of ingesting masses up to 24 times greater than the lug without blade failure. Tip seal downstream retention is maintained. Stackup analysis indicates seal is captured, and deflections are acceptable with all lugs fractured. This risk factor is an acceptable risk and is resolved for STS-29.
7	Fuel flowmeter rotor blades have predicted resonance between 2650 and 2870 revolutions per minute (rpm) resulting in inadequate fatigue life. HR No. INTG-042	Structural audit identified concern with forcing function from rotor/flow-straightener coupling. New dynamic analysis of the fuel flowmeter assembly indicates rotor resonance near 2800 rpm. The resonance is driven by an 18 rev forcing function from the upstream flow straightener. Hardware evaluation indicated the predicted fluid forcing function amplitude is unrealistically high. It does not drive the rotor blade to damaging levels of stress. The HCF endurance limit is greater than material yield stress; therefore, no fatigue damage accumulated during operation. Absence of residual stress, determined from x-ray diffraction, ensures a factor of safety on endurance greater than 2.0. This risk factor is not a safety concern for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SSME		
8	Engine 2 helium fill check valve on OV-104 failed in the open position. A second failure in the fill quick disconnect at liftoff would result in the loss of helium overboard. HR No. INTG-019 INTG-068 ***No anomalies reported on STS-29.***	There are several of this type check valve in the engine system. The failure mode is that the poppet cocks and jams in the spring guide. Two other check valves have also failed, but their failure at the time was assessed to occur only if the valve was subjected to high pressure differentials such as seen in the interconnect positions. An Operational Maintenance and Requirements Specifications Document (OMRSD) requirement was implemented to prohibit opening interconnect solenoid valves with differentials greater than 1000 pounds per square inch differential (psid). The OV-104 failure demonstrates that the high pressure differential is not the only cause of this failure, and studies for modification are in progress. The last time the check valve is operated is when going to flight pressure in the launch countdown. A leak would not be detected. This risk factor is an acceptable risk for STS-29 based on: - Tests show the valve is working correctly. - It requires a second unrelated failure to result in the Helium overboard dump. - The second failure would be detectable and allow time for abort procedures implementation. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>SSME</u>		
9	Several SSME valves have failed recently in modes that cast doubt on the reliability of the hydraulic actuators on the valves. Some actuator failures would result in catastrophic engine failure resulting in loss of the vehicle and crew. ***No anomalies were experienced on STS-29.***	The main oxidizer valve failed subsequent to a test at Stennis Space Center (SSC) on March 9, 1989. The cause is undetermined, but this type of failure could involve the hydraulic actuator. Also, two failures occurred in the laboratory on test units. One with 190,000 cycles was at the end of its life expectancy, and the failure was anticipated. The second with 40,000 cycles was not expected. These failures will significantly reduce the previously calculated reliability figures from the failure assessment prior to STS-26. Failure analysis and assessment performed by the Project indicated that the failures were probably due to contamination. There was no indication of a generic failure problem with these valves. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>SRM</u>		
1	An incident during QM-8 tests caused concern about Kapton insulation flammability and premature ignition of Redesigned Solid Rocket Motor (RSRM) propellant from igniter heater short circuit. HR No. FI-01 FC-01 ***The right aft field joint heater failed during the prelaunch period. The secondary heater was subsequently used and operated satisfactorily. The 20-ampere fast-acting circuit breakers will be implemented to protect this circuit for STS-30; 20-ampere instant trip Ground Fault Interrupts (GFIs) will be implemented for flights after STS-30.***	The probable cause was improper bending of heater tabs during installation. This has been alleviated by preforming the leads during manufacture by the vendor, through inspection and testing, and certification. Installation and inspection procedures were initiated to protect against short circuits. The circuit is currently implemented with a 25-ampere thermal magnetic circuit breaker which results in 210-amperes short circuit current and 2500-milliseconds clearing time. A 20-ampere instant trip GFI was recommended. KSC tests indicated no measurable short circuit current (1/4 A trip level), 500-millisecond clearing time, and no pitting of the SRM case. KSC is to implement 2 GFI units. Due to 10-week delivery for circuit breakers, the first unit will not be available until STS-28. This risk factor is an accepted risk for STS-29 and will become controlled upon implementation of the GFI equipment for subsequent flights.
2	The right-hand SRM Flex Bearing elastomer pad unbond area exceeds specification. HR No. BN-06 REV B ***No flight degradation and no anomaly was reported as of STS-29 MSE closeout date.***	Maximum allowable unbond area per pad is 20 square inches. Pad No. 2 had 75.8 square inches (1.27 percent of available area); Pad No. 3 had 36.3 square inches (0.61 percent of available area). The bearing was successfully acceptance tested. Bearing performance and integrity will not be affected. Successfully tensile leak tested. The bearing will be in compression during motor operation. A worst condition (116.7 square inches of unbond) was successfully fired on QM-8. This risk factor is not a safety concern for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SRM		
3	The right-hand SRM center aft segment does not meet the insulation void specification. HR No. BC-10 REV B *No anomaly reported on STS-29.*	The specification allows no voids in the insulation for the first 40 inches inboard from the tang end. Forty-five voids were identified within the insulation within the first 40 inches from the tang end. One void was identified in the stress relief flap. All void areas identified exceed the 1.5 minimum safety factor (SF) requirements; a minimum SF of 1.93 was calculated for the void with the lowest margin of safety. A minimum SF of 2.34 was calculated for cumulative void regions. Thermal analysis showed that the flap/propellant interface temperature in the area of void No. 30 (13.51 inches from the tang at 279 degrees) would not exceed 210 degrees Fahrenheit (F) during the time propellant is burning back to that location. RSRM propellant can be heated to 300 degrees F for 24 hours without igniting. This risk factor is not a safety concern for STS-29.
4	The left-hand SRM has a dented stiffener case segment. *No anomaly reported on STS-29.*	An indentation exists in the case wall at 319 degrees, 21.0 inches forward of the tang end of the case segment. Radius dimension checks 0.105 inches at the center of the indentation. The inside and outside surfaces were repaired by shot peening in the dented area to prevent any potential stress corrosion problems. The case passed magnetic particle inspection and proof test. The most critical position of the dent only causes the buckling safety factor to drop from 1.54 to 1.52. The corresponding drop in the margin of safety is from +0.09 to +0.08 (calculated using the required 1.4 safety factor). The analysis is conservative, because the stiffening effect of the propellant is not considered. This risk factor is not a safety concern for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SRM		
5	Both left- and right-hand SRM Safe and Arm (S&A) rotors have safe-arm rotation in excess of specification. HR No. INTG-142 ***No anomaly reported on STS-29.***	Torque required to rotate each unit is above the specification value. The assembled S&A devices have performed correctly, including the acceptance test procedure which tests the cycle response time. Even though the barrier booster torque was high, the Arming Monitors used in these assembles are able to drive the barrier boosters and ensure proper S&A device performance. Two companion devices tested using a procedure similar to that used at KSC cycled at 1.597 seconds and 0.995 seconds maximum, which met the 2-second requirement (this was at 24 Volts Direct Current (VDC) instead of the 28 VDC used at KSC). The S&As are limited to use in STS-29 motors. This risk factor is not a safety concern for STS-29 based on the test results.
6	Ligament cracks in the RSRM aft segment stiffener rings could propagate to allow structural failure of the case during pressurization at ignition. HR No. BC-09 INTG-158A ***Ligament cracks did not propogate on STS-29.***	Recovered hardware shows ligament cracks and failed bolts as a result of water cavity collapse loads at water impact. An aft segment failed during proof test where a stiffener ring had an inner ligament crack. Therefore, no stiffener rings with inner ligament cracks are approved for reuse. Outer ligament cracks in the stiffener rings may be approved for reuse and 10 segments with outer ligament cracks have been flown. Seven of these were along the centerline in an area of high stress, and two of these have been flown twice. Outer ligament cracks are not a flight safety concern since it is the inner ligament that reacts the ignition loads. The outer ligament reacts the water impact loads.

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SRM		
6 (Cont.)		The concern that has been raised is that stress corrosion could cause cracks on the inner ligament or cause these cracks to propagate to critical size, resulting in failure of the stiffener ring and, in turn, the case. All aft segment cases with stiffener rings are proof tested and inspected at Morton Thiokol prior to reuse. They are also measured for roundness, because flat spots in the ring could result in additional installation tension. The interval between the proof test and flight could exceed 12 months. The Project and Marshall Space Flight Center (MSFC) SRM&QA position is that the stiffener rings are safe to fly based on: - Screening by inspection and proof test at Morton Thiokol. - STS-29 rings had no inner ligament cracks. - Maximum case out-of-round is 0.080 inches, which is within the allowed 0.10-inch requirement. The STS-29 rings had an easy assembly that also supports low assembly loads. - TDC, a company under contract from Morton Thiokol to test the rings for residual stress, found the inner surface of the bolt holes to have a localized high residual compression load as a result of the proof test rather than the theorized residual tension load. - Stress corrosion is not a concern in a compression load. - Tests by MSFC Materials and Processes Lab to much higher levels than theorized in this investigation have found no evidence of stress corrosion. - The bolt holes are protected by grease virtually full time to exclude moisture and are closed out with K5NA. There is no record of having found evidence of corrosion post flight. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>SRM</u>		
7	Thirty-five of 100 QM-8 nozzle-to-case joint radial bolt Stat-O-Seals had unacceptable defects found on disassembly after the QM-8 test. This discovery caused concern that the Stat-O-Seals in the STS-29 SRMs may have the same defects and permit hot gas leakage. ***No anomaly reported as of STS-29 MSE closeout date.***	Enhanced inspection requirements using Military Standard (MIL-STD)-413 found defects described as "open flow lines" on the inner face of the seal. Some were circumferential, and others were radial. Previously flow lines were not considered a disqualifying defect per the inspection requirements. The severity of the flow lines found following disassembly of QM-8 are more severe than any found to date. It is unknown if the flow lines are present on the Stat-O-Seals on the STS-29 SRMs, but it is assumed that they are. Testing at Morton Thiokol found that seals with the open flow lines do provide a good sealing footprint, and seals with the worst case flow lines from QM-8 do seal during subscale pressure tests at both low and high pressure. Further, the metal in the seal has demonstrated the feature of providing an excellent metal-to-metal seal during tests using bolts with no shoulders during STS-26 processing. Leak tests on STS-29 were good, so it can be concluded that the seals will not leak. This causes no safety concern, and the risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SRB		
1	NSRS Report identified the fact that some B-nuts on SRB Hydraulic Power Units (HPUs) are not safety wired. HR No. INTG-028 ORBI-268 B-20-08 REV B ***Anomalies in SRB HPUs, which occurred during the STS-29 descent phase, are not attributable to this risk factor.***	Investigation of this issue found that two inspection port caps are not normally safety wired since the cap configuration certified has no provisions for safety wires. The Critical Item List (CIL) acceptance rationale was approved based on the caps being safety wired. The STS-29 caps came from the vendor with a safety wire provision and were safety wired. Use of the caps with a safety wire provision was approved, and future flights will have safety wired caps. Orbiter Auxiliary Power Units (APUs) have the same problem. The change was approved for the APUs, but will be implemented on Orbiter APUs as the opportunity presents itself. The decision was based on risk of damage to other components in accessing the caps. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
SRB		
2	SRB aft skirts Factor of Safety (FOS) are less than 1.4. The skirts also require reuse certification. HR No. INTG-158A ***No liftoff or ascent anomaly reported.***	Water impact recertification analysis of previously flown aft skirt is complete except for upper ring and gussets (not critical for prelaunch loads). Critical aft skirt welds were ultrasonically inspected with no anomalies in the critical area (bottom 8 inches of compression posts). Skirts were subjected to postflight inspection/Non-Destructive Evaluation (NDE), and all anomalous conditions were corrected. Preflight inspection levels were the same as those for STS-26 and STS-27. Holddown post modifications reduce stress by approximately 4%. An FOS of 1.28 has been approved for STS-29 (Level II directive). Comparison of aft skirt strain gages shows maximum stacking strains for STS-29 less than STS-26; therefore, mismatch is less severe for STS-29. Comparison of load indicator values without mismatch shows an FOS for STS-29 greater than STS-26 (57.8 vs. 59.1). Therefore, the FOS for STS-29 is no less than 1.28. This risk factor is resolved by analysis and tests which indicate an FOS of not less than 1.28 for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>ET</u>		
1	Blackish film was discovered on ET-29 aft dome gores when the LH_2 tank was entered to service clips holding the ECO sensor (on STS-30). HR No. P.06 ***No anomaly reported on STS-29 which was attributable to this risk factor.***	The film is a mixture of alkaline cleaner and irridite. The largest particle size that could be rubbed off was 25 microns. Cause for the blackish film was due to application of alkaline cleaner at too high a temperature. ET-29 is considered acceptable to fly with blackish film. Rationale includes: - Particle size much smaller than allowable (liquid oxygen (LO_2) filtered to 800 microns, LH_2 filtered to 400 microns). - Quantity is small. - Cryogenic testing did not dislodge particles. - Particles are inert. - Particles will not agglomerate. - Electrically nonconductive. - No degradation of irridite. - No valves in KSC ground system are expected to be affected on detanking. This risk factor is not a safety concern for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>ET</u>		
2	During STS-27 tank loading, gaseous hydrogen (GH_2) levels in ET Ground Umbilical Carrier Plate (GUCP) cavity exceeded Launch Commit Criteria (LCC) redlines. HR No. INTG-015 ***No anomaly reported on STS-29.***	The 7-inch Quick Disconnect (QD) was disassembled by a team of NASA, Shuttle Processing Contractor (SPC), Martin Marietta Corporation (MMC), and malfunction lab engineers. A seal was found to be missing between the bellows weldment and bellows guide. The 7-inch QD on STS-29 was removed from the ET. A new 7-inch QD was assembled, and all seals verified to be installed. As a result of this action, this risk factor is not a safety concern for STS-29.
<u>IUS</u>		
1	IUS computer "A" exhibited abnormal characteristics during integration testing. ***No anomaly reported on STS-29.***	It is believed that a chip in the line receiver is temperature sensitive. Forty chips were screened, and 17 tested OK. IUS computer "A" was replaced at the pad. It has been checked and is working satisfactorily. This risk factor is resolved for STS-29.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>IUS</u>		
2	IUS/Airborne Support Equipment (ASE) jettison versus SHARE clearance. ***No anomaly reported on STS-29.***	SHARE position tolerances were verified to the Interface Control Drawing (ICD)/design requirements utilizing instrument readings to the Orbiter coordinate reference. Worst case deviation was 0.12 inches in the vicinity of the IUS trunnion, and these data were factored back into the clearance assessment. Thermal effect on the longest IUS trunnion is 0.22 inches. Resulting trunnion to Hazard Reduction Precedence Sequence (HRPS) structure clearance for IUS/ASE jettison after SHARE EVA standard rotation is: static 0.3 to 0.7 inches, thermal 0.08 to 0.48 inches. With removal of rotation stops, the SHARE can rotate until it contacts the Orbiter sill structure (greater than 40-degree rotation); 40-degree rotation provides greater than 0.25-inches additional clearance. This risk factor is resolved for STS-29 as a result of the measurements and analysis performed.
3	IUS Aft Frame Tilt Actuator (AFTA) has single failure points which can cause a runaway condition. ***No anomaly reported on STS-29.***	During review of the FMEA, two new single-failure points were identified. These result in high current runaway and defeat the ability of the system or crew to respond. Safety concerns were analyzed, and all were found to have adequate controls available or alternate means of operation were possible. The investigation indicated that failure does not represent a safety hazard to the Orbiter; does not create load conditions in the IUS or TDRS which exceed liftoff and ascent design loads; and does not eliminate capability to complete the mission. Failure probability is estimated to be in the 1×10^{-6} range. This risk factor is resolved for STS-29 as a result of the analyses performed.

RESOLVED STS-29 SIGNIFICANT SAFETY RISK FACTORS SUMMARY LISTING

ELEMENT/ SEQ. NO.	RISK FACTOR	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>IUS</u>		
4	Two IUS centering spring fittings were found loose in the OV-103 payload bay. ***No anomaly reported on STS-29.***	Inspection of the OV-103 payload bay revealed two retaining screws in IUS centering spring fittings were loose. These were torqued properly, but appeared to back off during flight (Problem Report (PR) CM3-08-0123). Threads on retaining screws did not allow full seating into the retaining pin, which caused a gap under the fastener head. The fasteners were removed and replaced with modified fasteners which were torqued and lockwired. As a result of the action taken, this risk factor is not a safety concern for STS-29.
5	IUS ASE Y-damper was found to have leaked during STS-26. ***No anomaly reported on STS-29.***	Prior to removal of the Y-damper from STS-26 IUS at KSC, no leakage was evident. The leaking damper was shipped to the manufacturer for assessment. Investigation found that the Y-damper would not show leakage for up to half the quantity of fluid in the damper when the IUS is in the horizontal position. Leakage is readily detectable in the vertical position. Boeing reported that the procedure that checks Y-damper leakage in the horizontal is incorrect and changed the procedure to make the checks in the vertical in the future. The leakage rate that produced the 722 drops of leakage is unknown because it could have occurred undetected during any period over the 2-1/2 years since the last known rate. Loss of function of the damper due to leakage past the seals is extremely remote with the use of the new leak check procedures. This risk factor is resolved for STS-29.

Section 5

STS-27 INFLIGHT ANOMALIES

This section contains a supplementary list of significant inflight anomalies arising from the STS-27 mission. Each anomaly is briefly described, and risk acceptance information and rationale are provided. STS-27 inflight anomalies still considered as significant unresolved safety risk factors for STS-29 (if any) are addressed in Section 3.

STS-27 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
INTEGRATION		
1	Launch Systems Evaluation Program Team (LSEAT) program error could have given incorrect data upon which to base day-of-launch GO/NO-GO decisions. ***No anomaly reported on STS-29.***	Structural load indicators were incorrectly computed and displayed. The error was traced to an interpolation routine. The problem has existed since STS-8, but required the unique conditions of STS-27 to reveal itself. The error has been corrected by computer software modifications. Not a safety concern for STS-29.
ORBITER		
1	APU No. 2 Gas Ggenerator (GG) heater system A failed to respond when switched to A-Auto position. The crew selected heater system B, which appeared to fail on. The crew cycled heater system B, off and on again, after which the system functioned properly for the remainder of the mission. ***No anomaly reported on STS-29.***	During post-mission troubleshooting, cockpit switch 2A failed intermittently. The switch was replaced and sent to the vendor for failure analysis. Failure analysis showed the switch to be normal. However, the switch can be placed in a false detent position if the toggle is not positioned completely to hardstop. This anomaly is the result of a known characteristic of the switch. Crews have been briefed on proper switch operation. Not a safety concern for STS-29.
2	Right Reaction Control System (RCS) oxidizer "B" helium regulator response slow. ***No anomaly reported on STS-29.***	Flow data taken during postflight deservicing indicated the B leg regulator was defective. The vendor is conducting a failure analysis. The regulator was removed and replaced. Not a safety concern for STS-29.

STS-27 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
ORBITER		
3	Humidity separator B flooded. The crew reported that about two gallons of free water was discovered in and around the Environmental Control and Life Support Subsystem (ECLSS) bay. *No anomaly reported on STS-29.*	OV-104 humidity separator B was found to be nonfunctional due to a clogged pitot tube which prevented liquid water from being pumped out of the unit. Both OV-104 and OV-103 (STS-26) humidity separators were removed and sent to the vendor for testing. OV-103 humidity separator B functioned within specification as did OV-104 separator A. OV-103 humidity separator A was degraded (6 percent water carry-over vs 1 percent specified). A detailed analysis will be performed at the vendor, and results of both STS-26 and STS-27 will be tracked. Spare humidity separators were placed on board OV-103 for subsequent flights. Their humidity removal capability was successfully verified under the OMRSD in-flight maintenance workaround. Not a safety concern for STS-29.
4	During ascent and descent, hydraulic system No. 2 accumulator pressure read low. *No anomaly reported on STS-29.*	This failure was repeated in post-mission troubleshooting. The priority valve was removed and replaced. Failure analysis on the priority valve is in process. Not a safety concern for STS-29.
5	A carrier panel on the right Orbital Maneuvering Subsystem (OMS) pod was discovered missing during post landing tile inspection. *No anomaly reported on STS-29.*	Investigation revealed that this carrier panel did not have the correct hardware configuration. Washers were not installed, and the wrong length fasteners were used. KSC has performed an inspection of 95 OV-103 doors and carrier panels to verify correct carrier panel hardware configuration for STS-29. Job card documentation changes are also being made. Resolved for STS-29.

STS-27 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
ORBITER		
6	Cabin temperature controller 2 was nonresponsive. The crew reported that cabin temperature controller 2 was frozen and would not move when the cabin temperature selector position was changed. ***No anomaly reported on STS-29.***	The crew switched to controller 1 which operated properly. Four to 10 minutes are required for the actuator to go from full heat to full cool. The controller was probably at the low end of its operating range and may have appeared not to move, but was actually moving at a very slow rate. The controller was verified as working properly in postflight retest. Not a safety concern for STS-29.
7	LH_2 topping valve (PV13) showed simultaneous open/closed indications during dump and vacuum inert. ***No anomaly reported on STS-29.***	KSC could not duplicate the problem during post-mission troubleshooting. However, the component was removed and replaced. The failed valve was sent to the vendor for analysis. Not a safety concern for STS-29.
8	Tactical Air Command and Navigation System (TACAN) No. 1 (prelaunch) did not lock onto KSC ground station; TACAN cycled and then locked on with normal data. ***No anomaly reported on STS-29.***	Postflight troubleshooting failed to reproduce the anomaly. Two related problems have occurred on other TACAN units. A possible common link is that the TACAN channel select became latched up in a mode such that an improper or invalid channel was selected. The possibility of recurrence of such a latchup is considered extremely rare and can easily be cleared by a simple procedure. Not a safety concern for STS-29.
9	The Surface Position Indicator (SPI) "OFF" flag was visible, and the rudder position indicator appeared stationary at about 4 degrees left (bias 4^{o} left). ***No anomaly reported on STS-29.***	Postflight troubleshooting at KSC failed to reproduce the anomaly. The unit will be removed and sent to the vendor for additional testing. Not a safety concern for STS-29.

STS-27 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
ORBITER		
10	Certain Eaton/Dill pneumatic valve caps may cause loss of pressure. ***No anomaly reported on STS-29.***	The Eaton Corporation advised that valve caps with P/N MS20813-1 and the trademark "Dill" stamped into them may cause loss of pressure. All wheels and gear struts on all Orbiters were inspected for valve cap configuration. Critical areas of all flight Elements had their valve cap configuration verified and corrective action implemented, as required. Approved Dill, Schraeder, and Hydrofitting caps are available for use. SPC logistics has purged their stock of the suspect valve caps. Not a safety concern for STS-29.
11	Left OMS gaseous Nitrogen (GN_2) isolation valve coil failure. ***No anomaly reported on STS-29.***	The left OMS GN_2 tank showed a pressure rise from coil heat of about one-half of the rise normally seen. Troubleshooting at KSC revealed no anomalies in the valve or power to the valve. Review of data indicates this was seen on previous flights. There was no impact during the mission. Not a safety concern for STS-29.
ET		
1	During closure of External Tank (ET) doors, no ready-to-latch (RTL) No. 2 indicator was received. Nos. 1 & 3 received properly. No. 2 RTL limit switch signals on the left ET door failed to go high. ***No anomaly reported on STS-29.***	Found open fuses, bare wires, and broken connector backshell. The switch has been repaired. Door closed talkback requires a 2-out-of-3 vote from the RTL signal. The only function of the RTL signal in question is to provide 1 of 3 votes. If 2 of 3 RTL signals are lost and the ET doors can be verified to be closed, the ET doors can still be latched. Not a safety concern for STS-29.

STS-27 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
SRB		
1	Shoe shims missing. STS-27 post-flight inspection results showed that the EPON shoe shims were partially missing. *No anomaly reported on STS-29.*	The postflight inspection showed no scorching of the shoes, and the substrate was clean. This is indicative of loss at water impact rather than during early ascent. Therefore, the missing shims are not considered a debris problem. Resolved for STS-29.
2	Rate Gyro Assembly (RGA) shock exceedence. ***Reuse issue. The components must be certified prior to each launch.***	The pyro shock level of the RGA is exceeded at RH frustrum separation. This exceedence is comparable to a similar pattern recorded on STS-51F. Level II Program Review Control Board Document (PRCBD) S40443A limits use of RGAs to one flight, and all STS-29 RGAs are new. SRB RGAs function only during ascent. The observed exceedence occurs during decent at frustrum separation. Not a safety concern for STS-29.
3	Thrust Vector Control (TVC) lower frame shock exceedence. ***Reuse issue. The components must be certified prior to each launch.***	Flight data reflects the defined SRB lower frame water impact shock loads (375 g) were exceeded during water impact on STS-26 and STS-27. Teardown analyses of the flown hardware have demonstrated that the design is acceptable for water impact environment. All TVC Line Replaceable Units (LRUs) on lower frames of STS-26 and STS-27 have been inspected and show no evidence of damage. Hydraulic reservoirs are the only lower frame LRUs being reflown on STS-29. Refurbishment procedures ensure that these LRUs meet all flight requirements. Lower frames installed on STS-29 are new and certified for single mission use. Not a safety concern for STS-29.
SRM		
1	Fretting of field joint. ***Reuse issue. The components must be certified prior to each launch.***	Not a flight safety issue, but could impact case reusability which may create a safety concern for future flights. Not a safety concern for STS-29.

STS-27 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>SRM</u>		
2	Water found in STS-27 field joints. ***Reuse issue. Water was found on STS-29. However, the segment field joints must pass rigorous refurbishment and inspection.***	Suspected cause is a vent valve sticking open, allowing saltwater to enter after water impact. Seawater leakage through the vent valves was greatly reduced in volume compared to STS-26. This is a reuse/refurbishment issue which may create a safety concern for future flights. Fixes are being evaluated. Not a safety concern for STS-29.
3	Igniter heater discoloration. ***No anomaly reported on STS-29.***	Some heat damage and charring was evidenced by discoloration at two locations on both igniter heaters. The cause of this anomaly was improper routing of instrumentation wiring between the igniter heater and the igniter. This resulted in loss of the igniter wiring heat sink. The wire routing and closeout instructions have been changed to reestablish the heat sink. Wiring on igniter flanges was removed, heaters were installed, and the wiring was properly reinstalled over the heaters. This is resolved and is not a safety concern for STS-29.
4	Bolt damage in aft-fwd exit cone joint. ***Extensive damage was experienced again from STS-29 water impact. This is not a safety issue since the damaged parts are discarded. But loss of hardware is a concern which will be tracked outside of the MSE.***	This appears to be a random occurrence caused by splashdown and only affects the reuse of metal nozzle parts. Bolts are a single use item. Not a safety concern for STS-29.

STS-27 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
SRM		
5	Cork was missing from RH center field joint on STS-27. Breakup and debris could cause damage to the adjacent Space Transportation System (STS). HR No. INTG-037A ***No anomaly reported on STS-29.***	A Field Engineering Change (FEC) was written to perform fixes on STS-29. It includes drilling vent holes through the extruded cork. Recommendations include drilling of vent holes in the SRM joint cork bonding locations of Kevlar band buckles and pin retainer band trunions. The same cork should be inspected for internal low-density inclusion and repaired where detected. Tap tests and drilling have been completed. The safety risk is acceptable for STS-29.
SSME		
1	Liquid Oxygen (LOX) pump bearing anomaly. Cracked inner race found on No. 3 bearing of High Pressure Oxygen Turbopump (HPOTP) 9109R1 (STS-27 SSME ME-3). ***The condition of LOX pump bearing races was not reported as of the MSE closeout date. No anomaly reported on STS-29.***	The high-pressure oxidizer turbopump was removed from the engine and shipped to the vendor for failure analysis. Some contamination was found within the crack. Other small cracks were found in the bearing No. 4 inner race. Analysis determined that the crack in the bearing race occurred due to stress corrosion. The stress corrosion is a product of the stress due to an interference fit, chlorine contamination (despite cleaning measures), and moisture trapped in the cavity between the bearing race, spacer, and the pump shaft. Presence of the moisture is attributed to inadequate drying during the pump assembly. While no unique assembly conditions were found for the STS-29 pumps, borescope inspection revealed discoloration in two of the pumps. A decision was made by the NSTS Program Manager to remove and replace all three STS-29 HPOTPs on the pad. New processing requirements were implemented to improve drying procedures during pump assembly. The contact surfaces between the bearing races and spacers were also roughened to prevent a metal-to-metal seal from occurring.

STS-27 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>SSME</u>		
1 (Cont.)		The replacement pumps are assembled using a new drying procedure to preclude or minimize trapped moisture. New assembly procedures are being utilized to minimize the potential of stress corrosion. The STS-29 HPOTPs will be flown in a very short time after assembly, reducing the potential for stress corrosion to progress to critical flaw size (this is a time-dependent process). With changeout of all three HPOTPs, this problem is resolved for STS-29.
2	Hot gas temperature sensor failed on STS-27 flight. ***No anomaly reported on STS-29.***	HPFTP channel A temperature disqualified at approximately start plus 277 seconds. The sensor was retrieved and shipped to the supplier for analysis. Analysis/investigation results revealed a discontinuity in the element. The failure mode resulted in disqualification by the controller. Sensors are redundant. Current sensors have a very low failure rate. Redesign of sensors and thermocouples is being evaluated. Initial pull testing was inconclusive; additional testing is planned. More rigorous sensor inspection has been implemented. This is an acceptable risk for STS-29.

Section 6

STS-26 INFLIGHT ANOMALIES

This section contains a summary listing of the STS-26 inflight anomalies. Each anomaly is briefly described, and the resolution is addressed. Among these items are STS-26 anomalies that were discussed and considered as closed during the January 19, 1989 STS-29 Rollout Review.

STS-26 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
ORBITER		
1	Auxiliary Power Unit (APU) No. 3 low chamber pressure. ***No anomaly reported on STS-29.***	Analysis of the performance of APU-3 during the STS-26 mission has shown that it will continue to perform within specifications. Both the OMRSD and the LCC are being revised to reflect the minimum acceptable chamber pressure. Not a safety concern for STS-29.
2	Thermal Protection System (TPS) right wing damage. Approximately 6-inch x 12-inch x 18-inch damage of wing lower surface. ***See Section 4, ORBITER 1.***	Five tiles were replaced, and 1 tile repaired. MSFC has taken steps to minimize SRB/ET debris. This risk factor is resolved for STS-29. (See Section 4, ORBITER Item No. 1 for more details on the debris problem.)
3	Flash Evaporator System (FES). Ascent high load evaporator freeze. Entry FES shutdown. ***No anomaly reported on STS-29.***	FES Remove and Replace (R&R)/retest complete. The OMRSD was revised to delay removal of the FES duct plug until the end of the T-11 hour hold to minimize FES exposure to water condensation from the atmosphere. Borescope inspection of the FES cores will also be required prior to each flight. Not a safety concern for STS-29.
4	OMS Gimbal Standby Enable No. 1 failed during countdown. ***No anomaly reported on STS-29.***	An open circuit (loose wire in connector) found postflight was repaired/retested. The LCC was revised to permit loss of either primary or secondary controller on a given OMS engine. The design provides sufficient redundancy. Not a safety concern for STS-29.
5	Radar altimeter lost lock during landing. ***No anomaly reported on STS-29.***	Both units were recycled to the vendor. Low altitude receiver gain was adjusted, and units were returned to KSC and reinstalled. The units were flown on STS-27 and performed nominally. Resolved for STS-29.

STS-26 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
ORBITER		
6	KU-Band Deploy Assembly (DA) gimbal lock motor malfunction at low temperature. ***No anomaly reported on STS-29.***	The gimbal lock malfunctioned at low temperature (<15 degrees F). The lock failed to fully retract. The problem was isolated to inadequate brush clearance in the lock motor rate sensor assembly; an inspection point was missed at the vendor. Ten remaining lock motors at the vendor were inspected, and no problems were noted. Another unit has been installed for STS-29. A flight rule has been added to deploy the KU-Band DA and unlock gimbals as soon as possible after payload bay door opening. Temperature should be greater than 50 degrees F; unlock problems have only occurred at cold temperature. This anomaly is resolved for STS-29.
7	Measured peak delta P across OMS deck was higher than previous OV-103 flights (4% of OMS deck redline). ***No anomaly reported on STS-29.***	The concern is the potential for under predicting critical OMS deck frame load indicator for Day-of-Launch (DOL). Delta P versus mach history from STS-26 was outside of flight experience from four previous OV-103 flights. STS-26 peak delta P was within previous flight envelopes of OV-102. STS-26 loads did not violate 1.40 FOS on the OMS deck frame or 1307 bulkhead. Anomaly investigation cleared MPS leakage sources, instrumentation anomalies, payload leakages, and trajectory dispersions. The anomaly cause is unknown, but is possibly related to structural venting characteristics. It is treated as an additional dispersion parameter for STS-29 LSEAT. Development of OV-102 and OV-104 instrumentation requirements is in process. Ready to fly STS-29 and evaluate data for recurrence. Based on the investigation and analysis performed, this anomaly is not a safety concern for STS-29 flight.

STS-26 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>SRB</u>		
1	STS-26 Development Flight Instrumentation (DFI) data indicated a cavity collapse load on the RH Rock Servoactuator which exceeds the design yield of 173,000 pounds. ***Reuse issue.***	A load of 238,000-pound tension, 50-millisecond duration was indicated. Cavity collapse (post water impact) is a stress and not a fatigue environment; therefore, postflight inspection will detect failure caused by the environment. Teardown analyses of flown hardware demonstrated design is acceptable for water impact environments. Visual inspection and functional checks of Moog unit showed no problems. The piston straightness was well within specification. Vendor post-flight inspection and test showed no effect on STS-27 servoactuators attributable to this exceedence. All STS-29 servoactuators have passed physical inspection, functional tests, and proof load during refurbishment cycle. This is not a safety concern for STS-29 flight.
<u>SSME</u>		
1	GOX flow control valves on ME-1 amd ME-3 operated sluggishly. ***This is a repeat anomaly. It will be tracked in the STS-30 MSE.***	Valve components (all 3 valves) were removed, cleaned, their clearances increased to 0.0010/0.0012 inches, and reinstalled. The Orbiter system was borescoped during removal/reinstallation to verify cleanliness. (See Section 4, SSME No. 1 for more details on this problem.)
2	SSME-3 LH_2 inlet pressure erratic. ***No anomaly reported on STS-29.***	Transducer R&R/recessed connector pin was reworked. Retest complete. Not a safety concern for STS-29.
3	SSME LH_2 pressure erratic. ***No anomaly reported on STS-29.***	Sensor R&R and connector rework/retest complete. Not a safety concern for STS-29.

STS-26 INFLIGHT ANOMALIES

ELEMENT/ SEQ. NO.	ANOMALY	COMMENTS/RISK ACCEPTANCE RATIONALE
<u>ET</u>		
1	4-inch LH_2 Orbiter/ET disconnect leaked. Damaged seal. ***No anomaly reported on STS-29.***	Flapper seal R&R/leak check was completed. The flapper closure device was reshimmed to prevent recurrence. Not a safety concern for STS-29.
<u>GFE</u>		
1	Pilot/Mission Specialist No. 1 suit vent fan failed. Fuse blown. ***No anomaly reported on STS-29.***	The 3-ampere fuses were undersized. The suit fan motor power circuit protection was changed from 3-ampere to 5-ampere fuses. The design was recertified to use the 5-ampere fuses to provide margin at the high end of the nominal bus voltage. Not a safety concern for STS-29.
<u>IUS</u>		
1	IUS-7, stage 2 on the TDRS launched from STS-26 failed to arm. (A redundant unit performed, as required.) ***No anomaly reported on STS-29.***	Fault tree analysis concluded that rotor blockage due to contamination was the most probable cause. Margin limit tests (10 life cycles) were conducted on flight units, and afterward, both units were disassembled. No evidence was found to substantiate the suspected failure cause A nonflight aging surveillance unit built in 1978 was flushed with freon, and some particulates were found. Three test failures reportedly occurred in the early 1980s in a similar fashion to the IUS-7 unit. One failed due to hardening of potting compound, one a piece of loose wire, and one was nonconclusive. Subsequently, a new anticontamination and testing program was initiated. The current corrective action - in reality a screening test - resulted in a review of build papers and testing. All flight units have been subjected to 3-axis vibration and functional tests including 50 arm cycles. The risk is acceptable for STS-29/TDRS-D.

Section 7

BACKGROUND INFORMATION

This section contains pertinent background information on the safety risk factors and anomalies addressed in Sections 3 through 6. It is intended as a supplement to provide more detailed data if required.

Appendix A

STS-29 OFFICIAL INFLIGHT ANOMALY REPORT

This appendix contains the official listing of STS-29 inflight anomalies obtained directly from the NSTS Program Compliance Assurance and Status System (PCASS). Those anomalies which are considered to be significant safety risks will be addressed in the MSE for the next NSTS flight. However, for completeness and reference purposes, the entire anomaly list has been included here.

STS-29 OFFICIAL INFLIGHT ANOMALY REPORT

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
ET	01	. . PRELAUNCH P. MULLER/EE31	STS-29-T-1 . .	S	Excessive fluid was seen in the External Tank/Orbiter LH2 umbilical area during the prelaunch.
				B	During LH2 fast fill a large amount of vapor, visible liquid, and excessive frost was observed. Presently there are two possibilities accounting for the visible liquid; (1) liquified air - could be caused by insulation failure, bellows failure, or a restriction/suppression of the helium purge which would result in freezing around the purge cavity, (2) LH2 - could be caused by seal leaks (misalignment, seal flaws, etc). The visible liquid diminished after the reduced fill rate was reached. Also, the excess frost was gone when the Red Team viewed the vehicle. After main engine ignition, the frost fell from the disconnect area and was followed by a vapor trail. Explanation of the excessive fluids/vapors is continuing and is being tracked as an IFA by the KSC and Orbiter Projects also.
INTG/ORB	01	. . PRELAUNCH MARV COHN	. . .	S	Loss of data from multiple prelaunch balloons
				B	Upon release of the L-14 hour balloon at 5:07 p.m. CST on March 12, 1989, the weather station received "bad data" from the radar due to "garbage on the line." A second release

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
INTG/ORB	01				was made at 5:30 p.m. CST, but the weather station received no data. A third release was made at 6:00 p.m. (00:00:00 GMT) CST with radar data coming in on both lines and both worked perfectly, however, as a result of this 53 minute delay, the Julian date rolled over, but the date in the transmission header was not changed to reflect this. The Univac system saw no ill effects from this, but the MIDDS required a real-time fix of their software to accept the data. Communications technicians checked both lines and found nothing wrong. After release of the L-4.25 hour balloon at 2:52 a.m. CST on March 13, 1989, "garbage on the line" problems similar to the above were noted. This balloon was abandoned. Technicians cleaned and reseated circuit cards in the synchronous to asynchronous data converter. A second release was made at 3:15 a.m. CST with data flowing on both lines. No further problems of this type were experienced. The L-2 hour balloon is normally dual tracked for the first 50 minutes after which, one radar drops track to pick up the L-70 minute release. Somehow the data lines were reversed so that the tracking of the L-2 hour balloon was terminated at 43,000 feet. The problem was not discovered until the L-70 minute balloon was released and no data was being received on the expected line. By the time the problem was

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
INTG/ORB	01				found the L-70 balloon was passing 17,000 feet. A re-release at 6:35 a.m. CST was successful. The balloon was dual processed on the MV7800 A and B, and program restart problems occurred on one computer. One computer worked well and data was processed on time. Had the L-2 hour and L-70 minute balloons been properly tracked, this processing problem would have caused data to have been incomplete on one balloon. This problem has been frequently observed, and apparently occurs during peak computer workloads.
KSC	01	3/13/89 PRELAUNCH	IPR 29RV-0293/0296 MPS S72-0685-01-02-046	S	GHE Supply regulator exceeded 4500 psi.
				B	During the Launch countdown (OV 103, STS29) on 3/13/89 at (9:50:00 GMT) the T-3 hr MPS helium bottle fill to flight pressure (2000 to 4400 PSIA max) resulted in the MPS engine two helium system supply pressure indicated 4500 psia. The SSME He TK 2 exceeded 4490 psi OMRSD requirement. S00FF0-070. PRESS He TKS to FLT pressure limit (4490 psia) and the engine two helium supply pressure indicated 4500 psia. The pressure limit violation was caused by the MLP GSE Helium Supply panel S72-0685-1 primary regulator exceeding set pressure of 4350 psi

STS-29 OFFICIAL INFLIGHT ANOMALY REPORT

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
KSC	01				when the demand (to FLT press) was put on it. IPR 29RV-0293 was upgraded to a PR against the panel regulator. IPR 29RV-0293 was generated to document the GSE regulator problem and IPR 29RV-0296 was generated to document the overpressure of the flight helium tank (SSME TK 2). Status: The IPR was upgraded to a PR, an OMRS waiver (WK 1042) was approved and closed prior to launch. KSC LSOC Tracking Numbers: IV-6-014355
MOD	01	074:22:25. J. BRANDENBURG	. . MCC-01	S	Noise on A/G downlink.
				B	Beginning 74/2225Z, during crew sleep period, noise was heard in the MCC on the A/G loops at 75/0425Z. The noise cleared with no corrective action taken in the MCC. No problems were noted with telemetry data. DR # 061047. Resolution: Investigation into this anomaly has revealed that the airground voice system (AGVS) in the MCC was apparently locking to a bit pattern in the OD that is within the 2-bit error tolerance of the AGVS frame sync even though a good sync pattern was present. This theory was substaniated by replaying the recorded data through the AGVS with the bit

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
MOD	01				error tolerance set to zero; the correct frame sync pattern was locked to and no noise was present. The anomaly was recreated by adjusting the frame sync tolerance back to 2. Therefore, the conclusion is that the OD contained a bit pattern that was within the 2-bit error tolerance, which the AGVS locked to, thus skewing the voice bit pickup locations within the OD. There was no impact to the ongoing operations since the crew was asleep. Further, an active voice downlink would have cleared the problem. Procedurally, the MCC COMM TECH can clear the problem by reselecting SKR/AGVS interface and cause the frame sync to the correct word. This topic was addressed at the STS/TDRSS operations and procedures working group (STOPWG) meeting held on March 28, 1989 and it was noted by the network director that all other stations except the MCC and the ESTL implemented engineering change EC 4385-4061 dated 2/10/86 to set the AGVS bit error tolerance to zero. The MCC and ESTL were not included in the EC distribution and further investigation on the failure and the EC will be conducted. Status: Open. Further investigation required. Flight Problem Report approved at Level II Noon PRCB on 4/13/89. (PRCBD #S44957)

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER		PROBLEM NUMBERS		T C	TEXT LINE
MOD	02	072:14:58. J. SNYDER		. .	STDN-01	S	Degraded TLM during Plume.
						B	TLM Unusable from PDL during plume.
							Impact: Loss of TLM for approx 1 minute.
							Resolution: It was determined that the degraded OD TLM data was caused by an equipment problem with the mini shuttle launch support system (SLSS) between MIL/PDL. Testing on 15 and 16 March 89 at PDL has determined that there is a problem with the MFR to 336A bit sync interface associated with the SRLDS at PDL. Troubleshooting continues.
							Status: Open
							Flight Problem Report approved an Level II noon PRCB on 4/13/89. (PRCBD #S44958)
ORB	01	072:15:05. T. WELCH	ASCENT	IPR 33RV-0023 .	PROP-01 CAR 29RF02	S	RCS Jet R1U failed off during mated coast.
						B	Reaction control system jet R1U failed off during mated coast due to low chamber pressure. Trickle current test was performed and verified electrical path was good. Based on injector temperatures, the oxygen propellant valve is suspected to have failed closed.
							R&R required.

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER		PROBLEM NUMBERS		T C	TEXT LINE
ORB	01						Verified trickle current test OK. Thruster will be changed. Remove RH POD for repair. Scheduled for 4/17/89. Thruster removed and sent to vendor.
							KSC LSOC Tracking Number: PV-6-126066.
ORB	02A	072:14:57. D. CORCORAN	ASCENT	PR-APU-3-09-0178 PV-6-125563	MMACS-01 CAR 29RF03	S	Instrumentation - APU-3 EGT 2 Erratic (V46T0340A)
						B	Auxiliary power unit 3 exhaust gas temperature 2 dropped about 100 Deg during ascent, regained normal reading and dropped again post-MECO.
							KSC will trouble-shoot and R&R if required.
							Measurement will be verified during OMI V1019 testing.
ORB	02B	077:14:56. D. CORCORAN	POSTLANDING	PR-APU-3-09-0177 PV-6-125578	MMACS-03 CAR 29RF14	S	Instrumentation - APU 1 EGT 1 Failed (V46T0142A)
						B	Instrumentation - APU 1 EGT 1 Failed (V46T0142A)
ORB	02C	. . D. CORCORAN	ASCENT	PR EPD-3-09-1123 IPR 33RV-0022	. IM 29RF27	S	Instrumentation - SSME-3 Power Supply Temp (E41T3150A) erratic
						B	SSME 3 power supply temperature erratic from SSME start to shutdown. KSC T/S found wire

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ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	02C					pulled out of backshell of connector 50P446. Repair on PR. Repair has been completed, PR in closure.
ORB	03	072:17:06. D. DILLMAN	. .	EECOM-02 IM 29RF01	S	PRSD CYRO H2 Tank 3 Pressure High and Manifold Pressures Erratic
					B	The power reactant storage and distribution cryogenic hydrogen tank 3 pressure was erratic. Manifold pressures also indicated several pressure spikes. Similar behavior has been observed on other flights. Tank 3 put back into operation at MET 2:00:00 and tank and manifold pressures behaved normally for reminder of flight. Downey to provide analysis and written report to close problem at JSC.
ORB	04	072:14:57. S. MCMILLAN	IPR 33RV-0021 CAR 29RF04/29RF08	BSTR-01 CHIT J2951	S	OX FCV 1 Delayed start to open and FCV 3 opened slowly
					B	The oxygen flow control valves 1 & 3 had a delayed start to open and the oxygen flow control valve 3 opened slower than normal. Data showed that in subsequent cycles, the valves operated normally. Sluggish opening during the first open cycle has been observed on other flights.

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	04					Valves will be removed for inspection.
						Chit J2951 approved 3/27/89.
						Valves are scheduled for R&R on 4/12/89.
						Current trace test was performed on 4/7/89.
						Flow control valves have been removed. Valves sent to Downey for initial inspection and subsequently have been sent to the vendor (Eaton).
	05	072:21:19. D. SUITER	PR-DDC-03-09-0051 IPR 33RV-0026	INCO-01 IM 29RF05	S	PI Channel 1 Erroneous Reading
					B	Post TDRS deploy, the payload interrogator (PI) 1 started sweeping, which is an indication of a loss of PI Lock. The PI 1 channel 906 was reading 006 on the ground. During this time, Sunnyvale reported TDRS frame sync while the PI did not show lock, which is a known condition in the IUS CIU. Crew cycled thumbwheel for PI 1 channel, and PI locked with good data out.
						R/R A1L panel.
						Chit J2952 approved on 3/30/89.

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	05					Panel A1L is at the Rockwell Service Center (RSC).
						Panel A1L delivery back to vehicle week of 4/12. Retest on 4/17.
						Retest okay, will U.A. as a sticky thumb wheel.
						KSC Tracking Numbers: PV-6-125676
ORB	06	L-10 SECS. PRELAUNCH S. MCMILLAN	. IM 29RF06	BSTR-03 CHIT J2954	S	Excessive Vapor at H2 ET/ORB Umbilical Area Prelaunch
					B	Excessive vapor was seen in the hydrogen external tank/Orbiter umbilical area during prelaunch.
						Chit J2954 approved on 3/27/89.
						MSFC performing special tests. KSC to install a leak detector.
						Chit 2981 pending. Launch criteria being developed.
ORB	07A	073:19:28. D. SUITER	PR COM-3-09-0137 GFE/JSC/DR-EE649	INCO-03	S	TAGS Developer over heating

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	07A				B	An overtemp indication was received signaling a potential developer over heating. A test pattern was sent to the crew and the image revealed that the center heater was the cause of the indication. The system works nominally if powered up for use, and turned off between uses. Overtemp is expected to recur if powered up for several hours. Remove and replace and send TAGS to JSC for T/S. No further KSC action required.
ORB	07B	074:10:15. D. SUITER	. .	INCO-05	S	TAGS mode change
					B	At 074:10:15 GMT and 074:10:28 GMT, the TAGS moded from ready to standby during two separate page uplinks. The mode changes occurred at about the midpoint of the page. The TAGS commanded to ready, and in both cases, the TAGS went back to ready. Both pages were re-uplinked successfully. R/R TAGS. Has been shipped to JSC. No further KSC action required.
ORB	08	074:00:58. M. SUFFREDINI	PR-INS-A0020 GFE-DR-BH930037	INCO-04	S	OPS-2 Recorder Trk 4 Inoperable

STS-29 OFFICIAL INFLIGHT ANOMALY REPORT

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	T TEXT NUMBERS		C	LINE
ORB	08				B	OPS-2 recorder track 4 would not acquire sync lock when data was dumped. The recorder would not dump properly in forward or reverse at more than one site. Other tracks are OK. Remove and replace, and return recorder to JSC for T/S.
						Recorder removed on 4/10 and shipped to JSC.
ORB	09	077:10:59. J. GUTHERY	PR-0137 IPR 33RV-0025	MMACS-02 CAR 29RF07	S	PLBD Port B Close Indication Fail
					B	Payload bay door port aft close limit switch in the ready-to-latch module failed to indicate closed.
						Chit J2953 approved at 3/30 PRCB.
						Verified close indication still on.
						Switch module removed on 4/12. KSC to send module to Downey.
ORB	10	072:14:56. S. MCMILLAN	PR-HYD-3-09-0284 PV-6-125587	CHIT J2955 CAR 29RF09	S	WSB#3 Low relief valve reseat pressure.
					B	WSB#3 Relief Valve appears to have reseated, then developed a slow leak approx. 10 min later. It fully reseated at 26.7 psia. S/B 28 psia file IX in flight checkout requirement. Chit J2955 withdrawn.

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ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER		PROBLEM NUMBERS		TC	TEXT LINE
ORB	10						KSC will check-out during OMI V1017 testing.
ORB	11	. . S. MCMILLAN		PR-MPS-03-09-0285 PV-6-125588	CHIT J2955 CAR 29RF10	S	WSB#1 leak
						B	WSB#1 exceeded spec leak rate of .04 psi/hr. Subsequently, leak stopped.
							Chit J2955 withdrawn.
							KSC will checkout during OMI V1017 testing.
ORB	12	. . S. MCMILLAN	POSTLANDING	PR MPS-3-09-0673 .	CHIT J2954 CAR 29RF11	S	17 inch Disconnect leak
						B	Inspection discovered audible leak on 17 inch LH2 disconnect. Found nick on flapper seat. Black streak and small nicks on inner bore.
							Chit J2954 approved on 3/27/89.
							Inspection complete. Evaluation in process.
ORB	13	072:15:05. S. MCMILLAN		IPR 33RV-0028 CAR 29RF12	BSTR-04 CHIT J2954	S	LH2 4 Inch Disconnect slow to close
						B	The time from closed power (V41X1439E) applied to closed MSMT (V41X1420E) was approx. 5 sec spec is 1.2 sec. max.

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	13					Chit J2954 approved.
						KSC has chit in work.
						Bellville spring inspection good. R&R disconnect on 4/20 and ship to Downey. Rework and return disconnect by 6/15.
ORB	14	077:10:40. D. DILLMAN	IPR 33RV-0029 CAR 29RF13	EECOM-04 CHITJ2961A	S	FES Primary Controller "B" Outlet Oscillation.
					B	During 3 different startups on-flight the FES control temperature oscillated between 38 deg and 41 deg and damped out in approximately 6 cycles. Probable cause lies in the FES Primary B Control or midpoint temp sensors. This phenomena contributed to momentary FES shutdown during entry.
						Chit J2961A approved 3/31/89.
						Ramp tests performed on 3 mid point sensors. Pri. A lagged by 0.4 sec. Repacked and reinstalled sensors. Will retest. "B" side OK.
						Retest in-work on 4/19/89.

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		TC	TEXT LINE
ORB	15	076:19:37. M. SUFFREDINI	FIAR BFCE-211-F001 .	GNC-01	S	Plus X COAS Calibration Discrepancies
					B	A + X COAS Calibration was performed on flight day 3. Three + X calibrations were also performed on flight day 5 during DTO 790 using Vega, Denebola, and Arcturus. The three calibrations from flight day 5 differed from the flight day 3 calibration by 0.5 to 0.6 degree in the horizontal axis. Previous flight experience has shown that a COAS can be removed and remounted with essentially repeatable marks. JSC COAS at DWNY for evaluation. JSC doing sun filter test. No KSC action required.
ORB	16	074:08:45. D. DILLMAN	IPR 33RV-0009 IM 29RF16	EECOM-03 CHIT J2948	S	Fuel Cell #1 H2O Relief Valve Temperature Overshoot
					B	Crew configured fuel cell H2O relief heaters to the B auto position per the heater reconfiguration on the morning of flight day 3. The B thermostat immediately turned the heater on since its temperature was 70 deg F. The temperature rose to 130 deg before a normal cooldown of the H2O line was observed. STS-26 data on this thermostat showed that the temperature never rose above 105 deg F during its cycling when OV-103 was in a cool attitude.

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ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
ORB	16				Thermostat was removed and replaced at KSC prior to STS-29 flight.
					Chit J2948 approved. V1022 (PRSD system checks) will retest next week.
					KSC to work chit the week of 4/10/89.
					CHIT J2948
ORB	17	. . PRELAUNCH S. MCMILLAN	. . IM 29RF17	S	SSME #1 LH2 Prevalve signature anomaly
				B	SSME #1 LH2 prevalve signature was slow compared to previous operations.
					May be sample rate problem. No KSC action required.
ORB	18	T. WELCH	PR LP04-A0013 IM 29RF18	S	LH OMS Fuel gage ungageable quantity
				B	LH fuel gage total channel output had ungageable quantity locked in during OMS-2 and OMS-3. Readings were correct after deorbit burn.
					Deferred waiver WK0914 was approved prior to STS-29 for STS-29 only

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	18					OMS pod removal planned. Gage will be repaired.
						Totalizer check-out unit will be hooked up and gage tested week of 4/24 prior to pod removal.
ORB	19	J. GUTHERY	PR-PYRO-3-09-0101	CAR 29RF19	S	AFT Separation Hole Plugger did not Move Full Stroke.
					B	Postflight inspection at DFRC showed that the AFT separation hole plugger did not fully extend the piston.
						First failure since MOD - Debris in plunger was part of initiator.
						Downey to submit closeout to JSC.
ORB	20	075:07:18. M. SUFFREDINI	IPR 33RV-0008 IPR QA960036	INCO-07 CHIT J2968	S	Unable to dump OPS-1 Recorder, Track 2
					B	Data playback of OPS-1 recorder, Track 2 through TDRS & GSTDN unsuccessful. Data on adjacent tracks are locked up on with better results. Occurred again during postlanding dump of entry data. DFRF could not lock onto Track 2 data.
						Chit J2968 approved at 4/4 PRCB.
						KSC successfully dumped track 2. Chit in work.

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ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
ORB	21	. . S. MCMILLAN	. . .	S	MPS LH2 Feed Manifold Leak.
				B	Previous flights showed several relief valve cycles. This flight the relief valve cycled once.
					Investigation in process.
					Downey saw same profile last 103 flight. Providing rationale to JSC for problem closeouts.
					No KSC action required.
ORB	22	. . TOUCHDOWN J. GUTHERY	PR-MWA-22-0012 . . IM 29RF22	S	RH Main landing gear strain gage harness separation
				B	The RH main landing gear strain gage wiring and connector came loose and was found on runway. Suspected to have caused tile damage found on door.
					Terminal board not properly tied down in RH wheel well. Was proper on LH gear.
					KSC to replace terminal board. Reviewing tie-wrap photos.
					Configuration per drawing. Close out photos bad. Tie wraps installed properly.

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ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	23	. . S. MCMILLAN	PR-HYD-3-09-0282 PV-6-125371	. IM 29RF23	S	Hydraulic leak in aft compartment
					B	Postflight inspection found hydraulic fluid in the aft compartment. Inspection found loose "B" nut in leakage collection line from SSME-1 accumulator. One half to one ounce of hydraulic fluid found. Torqued "B" nut at DFRC for ferry. Will leak check again as part of OMI. KSC investigating why "B" nut loose. Paper work shows "B" nut torqued properly.
ORB	24	. . W. LEVERICH	IPR 33RV-0017 .	. IM 29RF25	S	Intermittent Aft Auto DAP Light.
					B	During crew debriefing the crew stated that on one occasion the Aft Auto Dap Light was not illuminated while the forward Auto Dap Light was illuminated. A lamp test indicated that the lamp was operational. At some point later it was noted by the crew that the Aft Auto Dap Light was illuminated. KSC will T/S per IPR.

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	25	. . J. GUTHERY	PR-TCS-3-09-1158 PV-6-125876	. IM 29RF24	S	Aft (1307) bulkhead thermal blankets loose and excessive particulate contamination in payload bay.
					B	KSC inspection found top (2) blankets torn on bulkhead side. Found loose snaps on top of blankets found total of (4) blankets peeled back. Two each side of upper CL. Suspected cause increase in air volume under blankets after 1307 beefup MOD. For STS-30/OV104, will install air vent screens in top two blankets. OV103 will remove all blankets and map entire 1307 bulkhead for damage and debris. Twelve blankets pulled and debris mapped. Wait for any further action on OV-103 MCR 14725 Downey MOD. Complete engineering by next week. Excessive contamination cleaned up. Inspection and clean-up plan for OV-104 in work.
ORB	26	. . S. MCMILLAN	. .	CHIT J2956 IM 29RF26	S	HYD System 1&2 Accumulator Ascent press locked up low.
					B	During STS-29 Ascent at APU shutdown, Hydraulic system #1 and #2 GN2 Accumulator pressures locked up low, 2496 psia and 2464 psia respectively and then crept up to acceptable levels (2600 psia). Chit J2956 PRCB 4/6 appd. Monitor lock up pressure during each OMI V9002 operation.

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ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS		T C	TEXT LINE
ORB	27	. . D. SUITER	IPR 33RV-0007 .	. IM 29RF28	S	TACAN #2 dropped lock postlanding
					B	TACAN #2 lost bearing and range lock postlanding. Will be R/R week of 4/17.
ORB	28	072:15:09:51 S. MCMILLAN	. .	. IM 29RF29	S	LH2 OUTBD Fill and Drain valve slow closing at dump termination
					B	LH2 outbd fill/drain valve slow close at dump termination. 11.5 actual vs 10 sec. spec. was observed in post flight data review. LCC changed to 13 sec. for liftoff. Engineering review in work.
ORB	29	. . D. SUITER	. .	.	S	Wireless Comm Set Multiple Battery Changes
					B	Crew reported changing batteries too often. Batteries known to be marginal. This lot of batteries removed from flight status. Better lot available. New battery design in process.
ORB	30	. . J. GUTHERY	. .	.	S	RH Outboard Brake Rotor Crack
					B	Post flight inspection of RH outboard brake assembly found a crack in

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
ORB	30				the rotor. This occurred during the hard braking OTO and was not unexpected.
SRB	01	. . R. HENRY/EE11	STS-29-B-1 PV-6-124593 .	S	Extensive damage to the left SRB TVC components was found during the postflight inspection.
				B	The TVC components' damage is considered to be a hydrazine reaction/fires during descent of SRB. Damage to the Tilt system is as follows: APU fuel pump ruptured, APU inlet hose missing, Fuel Isolation Valve (FIV) ruptured, FIV supply hose ruptured, and the 1/4" vertical drain line ruptured.
					Flight Problem Report approved at Level II Noon Board on 4/11/89. (PRCBD #S44950)
SRB	02	. . W. MANN/EE11	STS-29-B-2 . .	S	A structural crack of about 3 inches was found in the left Aft Skirt intermediate ring cap near HDP #8.
				B	Inspection revealed several areas of missing foam around the intermediate ring. The ring cap crack completely penetrated at the filet radius runout. Damage is attributed to the greater than usual water impact loads of the left SRB. A metallurgical examination of

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	TC	TEXT LINE
SRB	02				the fracture surface also indicated the fractured occurred due to impact loading.
					Flight Problem Report approved at Level II Noon PRCB on 4/11/89. (PRCBD #S44951)
SRB	03	. . R. HENRY/EE11	STS-29-B-3 PV-6-124599 .	S	Extensive damage to the right SRB TVC components was found during the postflight inspection.
				B	The TVC components' damage is considered to be a hydrazine reaction/fires during descent of SRB. Damage to the Rock/Tilt systems is as follows: APU fuel pump ruptured, APU fuel inlet hose ruptured, and FIV ruptured. The damage is attributed to the entrainment of SRM exhaust products and the subsequent hydrazine fires.
					Flight Problem Report approved at LV II noon PRCB on 4/11/89. (PRCBD #S44952)
SRB	04	. . W. MANN/EE11	STS-29-B-4 . .	S	The Debris Containment System (DCS) plunger did not properly seat at HDP #8 during liftoff.
				B	Postflight inspection of HDP #8 identified several debris chunks missing; most of the NSI Booster Cartridge and three large slivers of

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
SRB	04				the Frangible Nut. Follow-up inspection at the pad found debris in the post #8 sand pit similar to the description of the missing pieces, although the total weight of the debris discovered was only 1.6 ounces. The films of the liftoff sequence showed debris in the vicinity of HDP #8 area but remains under discussion as to conclusions.
					Flight Problem Report presented to Level II Noon PRCB on 4/17/89. A rewrite was requested. Rewrite was received on 4/18 and submitted for approval and signature out of board.
SRB	05	W. MANN/EE11	STS-29-B-5	S	Super Light Ablator (SLA) 220 was missing from the sloped face of the RSS antenna away from the orbiter (-z axis) of the left SRB.
				B	A 6 1/2 in X 5 1/8 in area accounting for 75% of total missing material is due to an adhesive failure. An additional 25% of the SLA 220 failed cohesively. A small area of substrate had minor sooting present, although the majority was clean (indicative of water impact failure). The sooting most likely occurs during reentry as the SRB is "burping" from remaining fuel consumption.
					Flight Problem Report approved at Level II PRCB on 4/13/89. (PRCBD #S44954)

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
SRB	06	. . R. RUNKLE/EE11	STS-29-B-6 . .	S	The SRB Back Up Ring (to Ordnance Ring Mounting fasteners) had missing and fractured nuts on both SRB's.
				B	The following damage occurred on the Right and Left SRBs: Right - 2 nuts missing and 1 cracked (all nuts are 5/16"); Left - 1 nut missing and 1 cracked (all nuts 5/16"). The damaged nuts were approximately 180 degrees apart on both SRBs. There are 120 fasteners installed on this mounting ring. Damage to these fasteners has been recorded on 7 of 54 frustrums flown. The damage does not affect the function of frustum separation.
					Flight Problem Report approved at Level II noon PRCB on 4/13/89. (PRCBD #S44955)
SRB	07	. . R. RUNKLE/EE11	STS-29-B-7 . .	S	A foreign object was seen while watching the film of the main parachute deployment.
				B	Postflight review of the parachute deployment from the Forward Skirt Dome mounted camera identified the following sequence of events. Approximately 0.25 second after initiating frustum separation command and during main parachute deployment, a foreign object was observed to cross the camera field of view. The object is visible for approximately 0.04 second. It first appears in the lower right

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER		PROBLEM NUMBERS		T C	TEXT LINE
SRB	07						corner of the field of view at an estimated height of ten feet above the Forward Skirt Dome. The object is cylindrical (and hollow) in shape. Evaluation of the film has determined that the object is a parachute deployment bag lacing grommet. Examination of the deployment bags revealed that one grommet was missing. The location of the missing grommet correlates with the flight direction of the object in the film. Grommets are damaged every flight due to the violent motion inherent in parachute deployment. This particular damage is well within the experience base. This is not an ascent issue, nor does this type of damage interfere with parachute deployment. Flight Problem Report approved at Level II Noon PRCB on 4/13/89. (PRCBD #S44956)
SRM	01	3/12/89	PRELAUNCH	STS-29-M-1 IPR 29RV-0289	CPWR	S	The primary heater current to the RH Aft Field Joint heater showed no voltage and a gradient temperature decrease during the countdown. The secondary heater was subsequently brought on.
						B	Investigation through the roostertail (area where the systems tunnel passes over the Aft Skirt/SRM) indicated an open circuit of the primary heater. Physical examination of the voltage supply cable to the heater cable

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
SRM	01				connector revealed that all four wires (2 positive, 2 negative) running from the heater to the "pigtail" connector had overheated, and a 5/8 to 1 inch area was melted away and missing. These components have been submitted to the KSC malfunction Analysis Laboratory for evaluation. Results pending.
					KSC tracking numbers : IV-6-014349, PV-6-124294
					Flight Problem Report approved at Level II Noon PRCB on 4/13/89. (PRCBD #S44960)
SRM	02	J. TRENKLE/EE51	STS-29-M-2	S	Postflight inspection of the Left Aft Center Factory Joint revealed several adhesive unbonds of the EPDM vulcanized weather seal.
				B	All unbonds of the weatherseal were adhesive failures (not cohesive). It appears that contamination is the likely mechanism which prevents an acceptable bond of the SRM case to the Chemlok (bonding agent upon which the EPDM weather seal is vulcanized). Inspection of the pin retainer band verified no damage/breakage, but the band was noted as nominally stretched. Radial expansion of the band is expected during pressurization of joints.
					KSC Tracking Number: PV-6-124361

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
					Flight Problem Report approved at Level II Noon PRCB on 4/12/89. (PRCBD #S44961)
SRM	03	B. POWERS/EE51	STS-29-M-3	S	The fiberglass phenolic liner was almost totally removed from the Aft Exit Cone shell of the Left SRB.
				B	The missing liner resulted in the most exposed aluminum seen on an exit cone including STS-1. Investigations are ongoing to evaluate the correlation of the nozzle jettison effects at apogee on the exit cone liner (nozzle jettison at apogee has been performed on STS-1 and STS-29 only). The primary conclusion at present is that the damage resulted from water impact (the Left SRB experienced greater water impact loads).
					Flight Problem Report approved at Level II noon PRCB on 4/13/89. (PRCBD #S44962)
SRM	04	M. ROSS/EE51	STS-29-M-4	S	Fretting corrosion was found on both Left and Right Case Field Joint Capture Feature interference surfaces.
				B	This problem is a recurrence from STS-26R and STS-27R. This is the first time that depths greater than 0.010" (established refurbishment specification) have been exceeded. The Right Aft Field Joint had a fretted area measuring

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
SRM	04				0.33"L X 0.22"W X 0.13" depth. Flight Problem Report approved at Level II noon PRCB on 4/13/89. (PRCBD #S44963)
SSME	01	E. JACOBS/EE21	STS-29-E-1 PV-6-124590	S	After landing, a leak in the MCC bond line was detected on ME-1, S/N 2031.
				B	Internal leakage at MCC to nozzle interface (joint G15) was discovered postflight of STS-29. Borescope inspection of the MCC bond line visually confirmed the leak location in the area of nozzle tube 630. A subsequent ultrasonic inspection shows one disbonded area of 0.4 inch wide (circumferential) by 0.09" to 0.12" forward, which intersects the aft feedslots. This delamination of the nickel plating over the copper narloy-z material reduced the structural integrity of the joint and the LH2 leak resulted. The engine has been removed and shipped to Rocketdyne. Flight Problem Report approved at Level II noon PRCB on 4/12/89. (PRCBD #S44959)
SSME	02		STS-29-E-2	S	During Disassembly of engine 2031 MCC/Nozzle joint, the G15 seal was found with blue discoloration in the area between tubes 54 and 80 (2.5 inch width)

ELEMENT	NO.	DETECTED/PHASE RESP.MANAGER	PROBLEM NUMBERS	T C	TEXT LINE
SSME	03	. . .	STS-29-E-3 . .	S	During disassembly of HPOTP unit 4105R1 (STS29R, ME-3), found 3 tip seal segments with gap greater than spec (0.0015 inches). Two segments were 0.002 inch gap, one was 0.003 inch gap. No screw rotation.
SSME	04	. .	STS-29-E-4 .	S	During disassembly of HPOTP unit 4105R1 (STS-29R ME-3), found two cup washers rotated past the stake.
SSME	05	.	STS-29-E-5 .	S	During disassembly of HPOTP unit 2222R1 (STS-29R ME-2), found three cup washers rotated past the stake.

Appendix B

LIST OF ACRONYMS

A/G	Air to Ground
A	Ampere
AFB	Air Force Base
AFTA	AFT Frame Tilt Actuator
AGVS	Air/Ground Voice System
AMOS	Air Force Maui Optical System
AOA	Abort Once Around
APU	Auxiliary Power Unit
ASE	Airborne Support Equipment
ATP	Acceptance Test Procedure
C-B	Collector-to-Base
CAR	Corrective Action Request
CHROMEX	Chromosomes and Plant Cells Division in Space Experiment
CIL	Critical Item List
CIU	Controller Interface Unit
CL	Center Line
COAS	Course Optical Alignment Sight
COMM TECH	Communications Technician
CR	Change Request
CRYO	Cryogenic
CST	Central Standard Time
DA	Deploy Assembly
DAP	Digital Autopilot
DCS	Debris Containment System
DFI	Development Flight Instrumentation
DFRC	Dryden Flight Research Center
DFRF	Dryden Flight Research Facility
DOL	Day of Launch
DR	Discrepancy Report
DTO	Detailed Test Objective
DWNY	Rockwell/Downey
EC	Engineering Change
ECLSS	Environmental Control and Life Support Subsystem
EGT	Exhaust Gas Temperature
EST	Eastern Standard Time
ESTL	Electronic Systems Test Laboratory
ET	External Tank
EVA	Extravehicular Activity

F	Fahrenheit
FCS	Flight Control System
FCV	Flow Control Valve
FEC	Field Engineering Change
FES	Flash Evaporator System
FIV	Fuel Isolation Valve
FLT	Flight
FMEA	Failure Modes and Effects Analysis
FMEA/CIL	Failure Modes and Effects Analysis/Critical Items List
FOS	Factor of Safety
FRR	Flight Readiness Review
GFI	Ground Fault Interrupt
GG	Gas Generator
GH_2	Gaseous Hydrogen
GHe	Gaseous Helium
GMT	Greenwich Mean Time
GN_2	Gaseous Nitrogen
GOX	Gaseous Oxygen
GSE	Ground Support Equipment
GSTDN	Ground Space Flight Tracking and Data Network
GUCP	Ground Umbilical Carrier Plate
H_2O	Water
HCF	High Cycle Fatigue
HDP	Holddown Post
He	Helium
HPFTP	High Pressure Fuel Turbopump
HPOTP	High Pressure Oxidizer Turbopump
HPU	Hydraulic Power Unit
HR	Hazard Report
HRPS	Hazard Reduction Precedence Sequence
HYD	Hydraulics
ICD	Interface Control Drawing/Document
IFA	Inflight Anomaly
IMAX	IMAX Systems Corporation
INTG	Integration
IPR	Interim Problem Report
IUS	Inertial Upper Stage
JSC	Johnson Space Center
KSC	Kennedy Space Center

L-2	Launch Minus 2 Day
LCC	Launch Commit Criteria
LCF	Low Cycle Fatigue
LH	Left-Hand
LH_2	Liquid Hydrogen
LOX	Liquid Oxygen
LO_2	Liquid Oxygen
LRU	Lowest Replaceable Unit
LP	Launch Pad
LSEAT	Launch Systems Evaluation Advisory Team
LSFR	Launch Site Flow Review
LSOC	Launch Site Operations Center
MCC	Main Combustion Chamber; Mission Control Center (JSC)
ME	Main Engine
MECO	Main Engine Cut Off
MET	Mission Elapsed Time
MIL-STD	Military Standard
MLG	Main Landing Gear
MMC	Martin Marietta Corporation
MOD	Mission Operations Director; Modification
MPS	Main Propulsion System
MSE	Mission Safety Evaluation
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NDE	Nondestructive Evaluation
NLG	Nose Landing Gear
NSI	NASA Standard Initiator
NSRS	NASA Safety Reporting System
NSTS	National Space Transportation System
NWA	Nose Wheel Assembly
OASIS	Orbiter Experiments Autonomous Supporting Instrumentation System
OD	Operational Downlink/Downlist
OMI	Operations and Maintenance Instruction
OMRS	Operations and Maintenance Requirements Specification
OMRSD	Operational Maintenance Requirements and Specifications Document
OMS	Orbital Maneuvering Subsystem
OPS	Operations
ORB	Orbiter
ORBI	Orbiter
OTO	One Time Only
OUTBD	Outboard
OV	Orbiter Vehicle
OX	Oxygen

P	Pressure
PCASS	Program Compliance Assurance and Status System
PCG	Protein Crystal Growth
PDV	Pressure Disconnect Valve
PI	Payload Interrogator
PLBD	Payload Bay Door
PM	Polymer Morphology
P/N	Part Number
POGO	Pogo Suppression System
PR	Problem Report
PRCB	Program Requirements Control Board
PRCBD	Program Requirements Control Board Document
PRESS	Pressure
PRSD	Power Reactant Storage and Distribution
psi	Pounds Per Square Inch
psia	Pounds Per Square Inch Absolute
psid	Pounds Per Square Inch Differential
QD	Quick Disconnect
R&R	Repair and Replace
RCA	Radio Corporation of America
RCS	Reaction Control System
RGA	Rate Gyro Assembly
RH	Right Hand
rpm	Revolutions Per Minute
RSC	Rockwell Service Center
RSRM	Redesigned Solid Rocket Motor
RSS	Range Safety System
RTL	Ready to Latch
RTLS	Return to Launch Site
S&A	Safe and Arm
S/B	Standby
SF	Safety Factor
SHARE	Space Station Heat Pipe Advanced Radiator Element
SLA	Super Light Ablator
SLSS	Shuttle Launch Support System
SPC	Shuttle Processing Contractor
SPI	Surface Position Indicator
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SRM&QA	Safety, Reliability, Maintainability and Quality Assurance
SSC	Stennis Space Center
SSBUV	Shuttle Solar Backscatter Ultraviolet
SSME	Space Shuttle Main Engine
SSRP	System Safety Review Panel
STS	Space Transportation System

TACAN	Tactical Air Command and Navigation System
TAGS	Text and Graphics System
TAL	Transatlantic Abort Landing
TCS	Thermal Control System
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TK	Tank
TLM	Telemetry
TPS	Thermal Protection System
TVC	Thrust Vector Control
TWX	Teletype Wire Transmission
USBI	United Space Booster, Inc.
VDC	Volts Direct Current
WSB	Water Spray Boiler